SOIL-PLANT INTERRELATIONS AND VEGETATION BOUNDARIES ALONG AN ELEVATION GRADIENT IN A HUNGARIAN SODIC GRASSLAND

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Abstract: In a 30 m transect soil-plant interrelations and vegetation boundaries influenced by edaphic factors were studied with moving split window (MSW) techniques. Boundaries between vegetation patches were sharp lines on the basis of both visual observation and MSW analysis but the boundaries between the different soil sections separated by MSW analysis were wider. Factor analysis showed that in the four vegetation sections separated by MSW the correlation coefficients were significant between plant and soil at $p<0.01$.

Keywords: moving split window, transect, solonetz

Introduction

The soil-plant interrelations have great importance for both ecology (Begon et al., 1986) and agriculture as well (Nagy et al., 2007). The zonation of plant community patches and the establishment of their boundaries are closely related to the edaphic factors (Begon et al., 1986, van der Maarel, 1975). Following the need of improved automatic boundary detection between plant communities (Kent et al., 1997) we studied a series of typical Hungarian edaphic grasslands. In this paper we describe the soil-plant interrelations and the establishment of vegetation boundaries in the zonation of sodic grassland communities along an elevation gradient. Our hypotheses were: (1) each boundary of plant communities, visible in a field observation can be verified with numerical methods, (2) each boundary between sodic grassland communities is narrow.

Materials and methods

We established a 30 m long transect at Csikós-puszta (46°17'21"N, 20°38'8"E, Kőrös–Maros National Park) along an elevation gradient from *Bolboschoenetum maritimi* to *Salvio nemorosae-Festucetum rupicolae* plant communities, where elevation, soil salinity and soil moisture as well as the temporary water logging constituted the background gradients (Fig.1.A.). Vegetation and soil samples were taken in 300 contiguous quadrats, 10 × 20 cm size each. Percentage cover of the plant species was recorded in the quadrats three times in 2002.
Soil samples were collected from the centre of quadrats from 0-10 cm depth. The laboratory analysis of the soil samples - soil moisture (w%), pH, soil organic matter content (SOM), soluble Na^+ ion content - was carried out according to Buzás (1988) except electrical conductivity (EC) that was measured in 1:2.5 soil:water suspension with conductometer.
The moving split window technique (MSW; Webster, 1973) was used to detect and characterise the boundaries between communities and between the soil of the communities along the transect as described by Zalatnai and Körmöczi 2004, Körmöczi 2005. Squared Euclidean Distance (SED) function and the complement of Renkonen similarity index (DREN) were used to compare the two halves of the windows to make clear which factor is decisive in the development of the boundary zone in the transect.

The significance of the peaks was tested with the Z-score transformation of the values of the two functions (Cornelius and Reynolds, 1991). Plotting the average Z-score transformed values of the SED and DREN functions vs. the window midpoint position resulted in a profile diagram where a significant peak is identified as a vegetation boundary. We computed the values of the function in several scales (half window sizes) from 1 to 20. Average Z-scores greater than 1.65 are considered significant at $p<0.05$. The seasonal results were averaged in the profile diagram.

The measured abiotic parameters (elevation, pH, organic matter, soil moisture, soluble Na^+ ion content, EC) were also analyzed by MSW using SED function, but before the analysis they were standardized by the range. In the four vegetation sections separated by MSW (Fig.1.E.), we examined the relationships between the above abiotic parameters and the abundance values of plant species via factor analysis (Tóth et al., 1995). In each section we computed the Pearson-correlation coefficient between the respective first factors of abiotic parameters and of the frequency values of plant species with SPSS11.

Results and discussion

The peaks of MSW analysis (both vegetation and soil data) coincided well with the three visual boundaries of the plant community patches (Fig 1. A, D, E).

The boundaries were sharp lines between the plant community patches on the basis of both visual observation and MSW analysis (Fig.1.A,E) while the boundaries were wider between the different soil sections on the basis of the MSW analysis (Fig.1.D).

The pair-wise correlations were significant ($p<0.01$) between the measured abiotic parameters except between w% and soluble Na^+ ion content and between w% and EC (data not shown), indicating that the sodic grassland had very strong organization. The primary factor was the elevation, along which two basic segments can be delineated: the area of temporary waterlogging (also determining soil moisture content), covered by *Bolboschoenetum maritimi* and the “dry” sodic segment starting with *Artemisio-Festucetum pseudovinae* community. *Puccinellietum limosae* community was covered only occasionally by standing water. The secondary factors of soil salinity, sodicity and alkalinity were very strongly correlated in this solonetzic soil, showing minimum mean values in the dry community of *Salvio-Festucetum rupicolae*, maximum in the *Pucccinellietum limosae* and smaller mean in *Bolboschoenetum maritimi*. Soil organic matter was limited by salinity, consequently showed the minimum in the *Puccinellietum limosae* and maximum in the highest part (Fig.1.B).

The results of the factor analysis showed that in the four vegetation sections separated by MSW the correlation coefficients were significant ($p<0.01$) between the soil parameters and the abundance values of the plant populations (data not shown).

At the first boundary, between the *Bolboschoenetum maritimi* and *Puccinellietum limosae* there was significant peak only with DREN function (Fig.1.E). Because DREN is more sensitive to the changes of the species composition than SED (Körmöczi, 2005) it seemed that in this point the compositional change was larger than the abundance change (Fig 1.E) due to the few species (4-5 species per communities). At this boundary the analysis of the soil parameters did not show significant boundary because only the soil moisture and the soil organic matter changed considerably, soil salinity did not change but had large variability in this section (Fig 1. B, C).

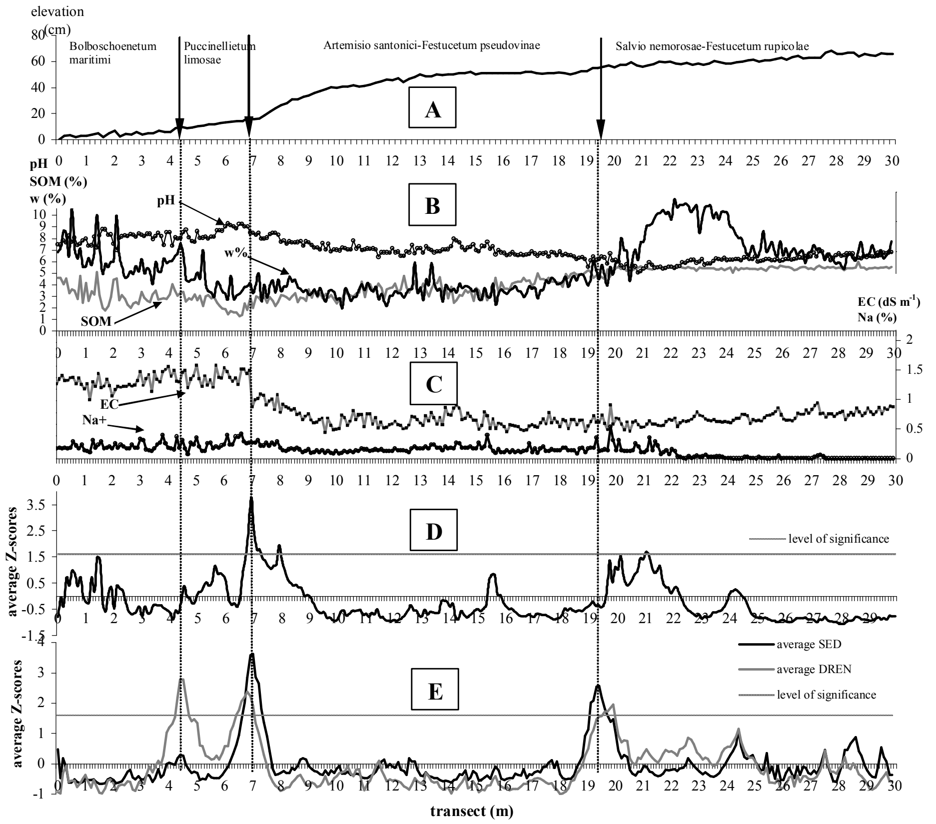

Figure 1. **A.** Elevation profile of the transect. Arrows indicate the visually detected boundaries of the plant communities. **B.** Changes of soil moisture (w%), soil organic matter (SOM) and pH along the transect. **C.** Changes of EC and Na^{+} ion content– along the transect **D.** The Z-score profile diagram of the soil data along the transect. **E.** The Z-score profile diagram of vegetation data with SED and DREN function along the transect. Dotted vertical lines belong to the peaks of the Z-score profile of the vegetation data.

At the second boundary between *Puccinellietum limosae* and *Artemisio-Festucetum pseudovinae* the MSW analysis showed significant peaks of both compositional and abundance changes (Fig.1. E) in the same position of the transect which coincided with the visual boundaries, too. The MSW analysis of the soil parameters (Fig1.D) showed significant twin peaks (between 7 and 8 m), which showed a wider boundary according to Körmöczi 2005. At the twin peaks there were abrupt changes in the values of each soil parameter but between the two peaks there were continuous changes.

At the third boundary between the *Artemisio-Festucetum pseudovinae* and *Salvio-Festucetum rupicolae* there were significant peaks with both SED and DREN in the same position (19.5 m) (Fig.1.E), which coincided well with the visual vegetation boundary. In the MSW profile of the soil parameters significant twin peaks emerged (between 20 and 21 m) which can be considered as wider boundary (Körmöczi 2005). In this position of the transect at the first peak (20 m) all soil parameters changed together, at the second peak (21 m) only the values of the soil moistures increased in great extent while the others remained unchanged. The change in moisture widened the boundary. It is because the soil moisture is very sensitive to the elevation differences (Mile et al. 2001). In this section of the transect there was a small basin (5 cm elevation difference) (Fig.1.A) where the precipitation accumulated that was shown by the abundant occurrence of the mesophilous plant species, *Alopecurus pratensis*, which is unusual in this plant community.

Conclusions

All boundaries visible during the field observations could be verified with MSW analysis. The boundaries between the community patches were sharp lines on the basis of both visual observation and MSW analysis while the MSW-boundaries between the different soil sections were wider. Soil-plant interrelations are strong and both the species composition and the values of soil parameters are sensitive to the relief differences in this solonetz soil.

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