Summary of thesis submitted for the degree of Candidate of Science

SPATIO-TEMPORAL PATTERNS AND PATTERN TRANSFORMATIONS IN SAND GRASSLAND COMMUNITIES

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Introduction

Investigation of the vegetation of an area used to be started with a general description and identification of vegetation units, i.e. definition of the cenological state of vegetation stands. Cenological analysis of plant communities is based on the idea that the associations are natural units of the vegetation. They have been believed more or less homogeneous and static, discrete and distinguishable.

The series of heavy controversy, that started at the beginning of this century and has not been finished up till recently, pointed out that the plant communities can not be considered as discrete units as the individuals of a species. The spatio-temporal relations among community units are of quite different nature because they have no definite envelope, "skin", or this envelope is rather diffuse, and on the other hand they represent a much more complicated level of organization.

Distinction of plant communities in the field sometimes seems easy when the differences — physiognomic, textural — between two stands are significant, abrupt changes can be detected in their border zone. These ecotones form a real border between adjacent stands, but the units overlap for a certain degree. In the ecotones of very different communities — e.g. forest-meadow, aquatic vegetation-shoreline vegetation etc. — there can be discovered the scaling problem that the border line at a larger scale which is appropriate for vegetation mapping, will become more and more diffuse when smaller and smaller scales are used. At a scale of population or coalition, the detection of the border is quite dubious.

In the case of communities with very similar architecture, ecotones can not be recognized, and the objective spatial distinction between communities is very difficult. This fact led to the development of continuum concept of the vegetation. But indisputable that the cenological structure and the ecological state of two communities without definite border can be surely distinguished. However the question about the spatial pattern transformation in the border zone remains open.

Psammophyle grassland communities proved to be good objects for many ecological investigations. Their cenological structure is not too difficult and is rather well known. Their successional pathways are reticulate so they support various pattern transformations. The species number is low in these communities, patch size of the

mosaic like stands is small, so the cost of sampling process is low. The most important phenomenon of these communities in relation to the above problems is that their architecture is very similar.

The goal of this study was to contribute to the knowledge of scaling problems of patterns and processes. The following questions were set up:

What properties should be the basis of distinction of plant communities?

How do grassland communities scan and respond to an inhomogeneous habitat?

What is the spatial pattern of the communities, and what about the transformation of this pattern?

What are the properties of the transitional zones, and what is their temporal dynamics?

Material and methods

The study site

Investigations were carried out at the research field of the Ecological Department of JATE University, in the Bócsa-Bugac region of Kiskúnság National Park. The sample area was a 2.4 ha isolated part of a pasture that was fenced in 1976.

The soil of this grassland is loose sand and humic sand. A mosaic like pattern of sand grassland associations has been developed at the varying relief of the research area, and the size of the stands is usually small, the scale of vegetation units is 10 m. The largest difference of the elevation at the area is about 3 m, and the most frequent elevation difference is 1 to 1.5 m. This habitat enables in this way the frequent occurrence of transitional regions.

The xerothermic associations of the upper relief show a large architectural similarity by the vegetation cover (percentage cover values are 40 to 60 %) and by the average height (25 to 30 cm) of the vegetation. The studied communities should be distinguished syntaxonomically, but their physical border is not marked, not as conspicuous as the transition of even the mesophylic and xerothermic stands.

The following plant communities were identified at the sample area:

Festucetum vaginatae danubiale
Potentillo-Festucetum pseudovinae
Brometum tectorum
Molinio-Salicetum rosmarinifoliae
Lolio-Potentilletum anserinae
Cynodonti-Poëtum angustifoliae
Achilleo-Festucetum pseudovinae

The first four associations grew at the fenced area, while the others occurred only at the lower relief of the grazed field. Stands of *Brometum tectorum* occurred mainly on disturbed region, and their proportion was rather low, that is why this community was neglected.

Sampling methods

Most samples were taken from a 2.4 ha isolated part of a grazing field, but some of them originated from the nearby area of the pasture. Three important associations were studied in detail that are separated by the elevation, and show a distribution correlating with disturbation pattern. Studied associations are: *Festucetum vaginatae danubiale*, *Potentillo-Festucetum pseudovinae* and *Molinio-Salicetum rosmarinifoliae*. This sequence means also the elevation distribution, from the upper relief to the lower one. *Potentillo-Festucetum pseudovinae* developed at regions with stronger disturbance — intensive grazing — but the other two communities prefer undisturbed areas.

Relevés were taken for determining the structure and cenological state of the associations. Sampling unit size was 2×2 m, and the percentage coverage of each species was recorded. Sampling periods were usually in spring, early summer and autumn, depending on the phenological state of the vegetation.

Temporal dynamics of the vegetation was surveyed in permanent quadrates of 14 places. Number of sampling places in an association was proportional to the proportion of the area of the association, therefore 3 places were established in *Festucetum vaginatae*, 7 in *Potentillo-Festucetum pseudovinae* and 3 in *Molinio-Salicetum rosmarinifoliae*. Only 1 sampling place belonged to *Brometum tectorum*, but it was not included in the evaluation of the results.

Behaviour of border zones of the communities was studied with belt transect method. I used a 40 m long transect, 1 m wide, consisting of 1 m^2 contagious cells. Percentage coverage of species was recorded from each seasonally, during three years. This transect was laid along an orographical gradient because I assumed the best detection of transitions in this way.

Statistical methods

Relevés were analysed with multivariate methods. I made the numerical classification with agglomerative cluster analysis, where resemblance functions were percentage similarity and Euclidean distance, respectively, and clustering algorithm was average link (UPGMA).

Multivariate analysis was completed with principal component analysis (PCA) on the basis of correlation matrix of raw data. In the PCA scatterplot, the objets classified in the same community or belonging to the same sampling period were encircled, and in the case of time series trajectories of the centres of sample groups were shown, respectively. Coordinates of group centres were given by the averages of object scores belonging to certain PCA axes. In the scatterplot of transect samples, points representing the adjacent sampling units were connected.

I made only ordination analysis in the case of time series, and the objects or centres of groups were connected according to their chronosequence.

Diversity values were calculated with SHANNON-WEAVER index, and diversity ordering was performed on the basis of RÉNYI index. Diversity values were plotted against α parameter.

I used the following computer softwares: SYN-TAX III, NuCoSA and Div_Ord .

Climate diagram was drawn from data of Meteorological Station Kecskemét.

Summary of new result

In sand grassland habitats, on the basis of relief differentiation of stands of the three main plant communities only the *Molinio-Salicetum rosmarinifoliae* association could be distinguished. Elevation position of stands of *Festucetum vaginatae* and *Potentillo-Festucetum pseudovinae* is overlapping, their separation is difficult, but they can be distinguished with cluster analysis.

Separation of the stands on upper relief was affected by microtopographic conditions. While *Potentillo-Festucetum pseudovinae* stands were situated on larger flat areas — sometimes with light slope — , *Festucetum vaginatae* could be found on sand hills of steeper slope.

Maximum cenological distance of the studied communities decreased during the long term study. At the same time, the species number of each stand increased, relative increase was larger at the second half of that period. This could be explained with the homogenizing effect of the extreme environmental conditions.

Each of the seven stands of *Potentillo-Festucetum pseudovinae* community showed similar behaviour in the PCA-space. This was because the changes in species composition were similar. The subgroups did not overlap in the three dimensional factorial space, and the alteration of vegetation structure meant a successional process. The most "linear" structure transformation could be detected in the case of *Molinio-*

Salicetum rosmarinifoliae, while the "movement" of *Festucetum vaginatae* stands is rather small. *Potentillo-Festucetum pseudovinae* association was in an intermediate ecostate.

Dendrograms clearly show the significant separation of the first year samples, and the sharp changes related to those. Changes of the xerothermic grasslands between the second two years were slight, but more marked in the case of *Molinio-Salicetum rosmarinifoliae*. I observed a delayed response of later community, because its stands were in more favorite microclimatic conditions.

Species-cover diversity gradually increased in each of 14 stands, and this reflects — together with the increase of species number — to the changes of environmental factors, that resulted in the decrease of community stability.

Changes of climatic factors resulted in the most pronounced structural alterations in the stands of *Molinio-Salicetum rosmarinifoliae*, since those had the highest water demand. Because of the very precipitation poor period, their species composition tended to that of *Potentillo-Festucetum pseudovinae*. Stability of the community of wind grooves was the weakest among the given environmental changes.

Successional changes of stands of *Festucetum vaginatae* were more moderate than those of the other two communities. This could be because *Festucetum vaginatae* stands have grown under extreme circumstances, and they could have the highest tolerance to drought period, so their stability was the strongest among the given circumstances.

Isolation plaid a very important role in the successional changes of the fenced area of sand pasture community, *Potentillo-Festucetum pseudovinae,* that resulted in the significant decrease of vegetation cover, but the climatic changes determined the trends of secondary succession of this community.

Average of W indicator values showed a strong temporal change in *Molinio-Salicetum rosmarinifoliae*, i.e. the largest decrease of average water demand could be measured in this community. W-values of disappearing species were larger than those of new species. Average W-value of species leaving the community until 1987 was 4.33, while that of newcomers was only 2.13. This trend could be detected also in the case of *Potentillo-Festucetum pseudovinae*, but the differences were smaller. The new species appearing in the arid period were mostly annuals, or perennials with lower water demand.

Trajectories of changes in the PCA factorial space were different for the studied communities. Movements — distance and direction — of the points representing the stands of *Potentillo-Festucetum pseudovinae* were similar. Principal component scores correlated with some structural and environmental features, the closest relationship was computed between W-values and scores on the 1st axis.

The points of *Festucetum vaginatae* showed only a small fluctuation along the 1st PCA-axis, because its structure was hardly influenced by drought.

The three stands of *Molinio-Salicetum rosmarinifoliae* performed a rather different movement in the factorial space. Starting points were close to each other, but later they moved off significantly. Only in the case of two stands could be shown closer correlation between component scores and average W-values. The third point, however, only fluctuated in a small extent, because it was situated at the lowest relief of the sample area, where the water regime of the soil could remain favourable for longer time, that is why this stand could tolerate the precipitation deficiency.

Only weak correlation was between the W-averages and annual precipitation in each community. These refer to the alteration of the water regime of the area, but do not prove clearly direct effect of precipitation distribution on structural changes.

The species joined in three separate groups on the basis of interspecific correlations. The pairwise correlations were positive in two groups, but in the third one there was either no correlation or negative correlation between species. According to these groupings, only two units of the vegetation could be recognized.

Dominance distribution of the species is the basis for visual assessment of boundary zones. Vegetation of the studied transect vas species-poor, only 6 to 8 species were dominant, and about the half of the species was distributed on a wider range of the transect. Occurrence of several species was sporadic or in smaller patches. Distribution of many species was overlapping or they showed a continuous transition among vegetation patches. These species had positive interspecific correlation, and they are not suitable to locate the community border of xerothermic grasslands.

Neither the species turnover marked the border zone between xerothermic communities because there were no abrupt changes in species composition, and these two associations had several common species and similar environmental conditions. It was more pronounced in the wind groove region.

We can conclude from transect data, that most species had their own characteristic distribution along the transect. Populations either formed continuous stands or had smaller gaps because of the topography. Distribution pattern of species were developed by their vegetative and generative spreading, that were modified by the environmental factors — mainly soil moisture — and interspecific interactions.

Distribution ranges of the species belonging to the same community were very different, ant their overlaps supported a continuous transition among associations. Even the dominant species of neigbouring stands overlapped forming transitional zones of different width. This zone was 2 to 3 m wide between *Potentillo-Festucetum pseudovinae* and *Molinio-Salicetum rosmarinifoliae*, but often much wider between the two xerothermic communities.

To determine the boundary zone between two associations, we must use several methods, and their joined results should present the best approximation of position of borderline (-zone). These methods should be (1) visual assessment on the basis of vegetation structure; (2) assessment from distribution pattern of dominant species; (3) assessment from spatial species turnover; (4) assessment from multivariate analysis of species composition and environmental factors. In general the first two methods do not

give a sharp boundary, but the others can, and the median of the resulted border zone should be considered as the border line between two communities.

Reasons of above processes should be searched in certain populations, and mainly in perennials. Dominance structure of species changes during the vegetation period. Cover values of species depended on their life cycle and on environmental conditions. Two main behaviour types of perennials could be distinguished. *Festuca pseudovina* represented one type, both its cover values and its presence in the quadrates fluctuated, and as a result, its distribution range along the transect was very changing on both sides.

Another type was represented by *Potentilla arenaria*. Its presence in the transect cells was more or less constant, though the cover values changed a little bit. The important property of this type is the gradual disappearance from the border zone of dry communities. In respect of response to the background factors, I called the firs type "fast species", and the later one "slow species". Fluctuation and resilience of communities is probably due to "fast" species, and the successional processes should be caused by "slow" ones even if the later are subdominant. Such alterations of spatial distributions of populations cause the seasonal fluctuation of community boundaries.