

Spatial scale-dependence of ecosystem CO₂ exchange in three non-arborescent temperate vegetations

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ABSTRACT Our goal was to investigate the spatial scale-dependence of synphysiological measurements in three different vegetation types: a loess steppe grassland, a sandy grassland and a ruderal weed community. The former two are widely distributed in the Carpathian Basin and completed with the weed association these are well representing the Hungarian non-arborescent, herbaceous vegetation. To carry out the stand physiological measurements we have constructed gas exchange chambers of several sizes. This size series allowed us to investigate the scale dependence of gas exchange measurements. In all of the three investigated vegetation the variability of CO₂-assimilation showed spatial scale-dependence. The highest variability was seen at smaller scales (smaller chamber sizes). The variability of the spatial scale-dependence of the stand photosynthesis was the highest in the sandy grassland, the least organised out of the three investigated community.

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KEY WORDS

synphysiology
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We do not have any information on the physiological processes of associations between the infraindividual (individual) and landscape level. The reason of this is mainly the lack of suitable methods for investigating these processes. However according to the results of synphenetecal and vegetation dynamic studies (Bartha and Kertész 1998; Mucina and Bartha 1999), the most important processes can be detected at the scales of a few dm² or m² in non-arborescent herbaceous or grassland vegetations.

Natural grass and weed associations of different species composition, texture, spatial pattern, vegetation dynamics, physiognomy, architecture and physiology were investigated at the same spatial scale. *Festucetum vaginatae danubiale* sandy grassland, *Salvio-Festucetum rupicolae* loess steppe grassland and a ruderal weed association have been chosen as the object of investigations. Our objective was to answer the following question: Is there any scale dependence of the investigated synphysiological processes in these associations?

The essential part of this work was to develop CO₂ and H₂O gas exchange chambers suitable for measuring stand-size patches.

Materials and Methods

Vegetation

Coenological records were taken in the *Salvio-Festucetum rupicolae* association close to Isaszeg on a loess soil area. This vegetation generally has high productivity (Fekete et al. 2002). Records showed the dominant species as follows: *Festuca rupicola*, *Chrysopogon gryllus*, *Stipa dasyphylla*, *Cytisus austriacus*, *Carex humilis*. Coenological data (cover

by species) were analysed by the SYN-TAX package (Podani 1993). Results of a hierarchic (cluster analysis) and a non-hierarchic (PCoA) analysis are given. In both cases the Czekanowski-index were used. The four groups (*Festuca*-, *Chrysopogon*-, *Stipa*- and a *Cytisus*-group) were generated by PC, are the forms of differing of species dominance of *festucetosum sulcatae* subassociation.

Sample plots of *Festucetum vaginatae* association were investigated in typical stand at Tece-legelő, near Vácrátót. Productivity of herbaceous sand vegetation is low for edaphic reasons (Fekete et al. 2002). The stands can either be open with xerophilous bryophytes and lichens, dominated by a few tufts of *Festuca vaginata*, *F. domini*, *Fumana procumbens*, *Poa bulbosa*, or more closed and richer in species, e. g. *Festuca vaginata*, *F. domini*, *Stipa borysthena*, *Botriochloa ischaemum*. The stage of change of species composition is the "empty spots" among *Festuca vaginata* and other *Poaceae* tufts. In these spots change places in time the several therophytes, hemiterophytes, bryophyte-lichen synusiums with the hemikryptophyte species.

A fast growing ruderal weed association the *Convolvulo-Agropyretum* was chosen as the third object. It has developed on a several year ago abandoned area dominated by three typical weed species: *Artemisia vulgaris*, *Daucus carota* and *Agropyron repens*. Concerning to the relative water require and soil chemical reaction distributions of the species show the soil is semi-wet and neutral, reach in nutrient.

According to our unpublished data the difference in the maximum Florula diversity, max. number of species combinations, max. association organisation of dominant species in the three circumstance the loess proved the highly organised and the sand grasslands the less organised community and the weed is in the intermediate position.

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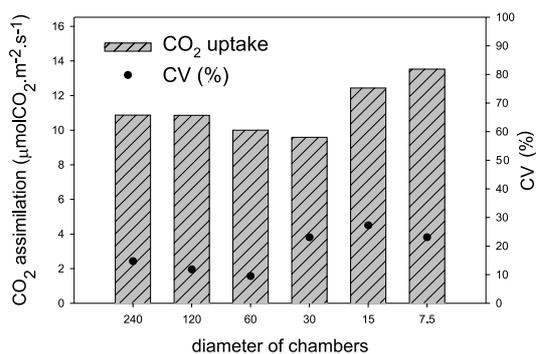


Figure 1. Spatial scale-dependence of net CO₂ uptake in the ruderal weed vegetation (17.10.2001., Gödöllő).

Stand CO₂ and H₂O exchange and other measurements

We measured the CO₂-exchange, transpiration, as well as air temperature, relative humidity and vapour pressure, and calculated stomatal conductance by using a portable closed-loop IRGA gas-exchange system (LICOR-6200) sampling the air in the plexi-chambers of different diameter with three replicate measurements in each plot. Canopy CO₂-assimilation rates were corrected by soil-surface respiration values. photosynthetically active photon flux density (PPFD) values were recorded and leaf area index (LAI) was estimated using sunfleck ceptometers (Decagon). Canopy-surface temperature was measured with an infrared thermometer (Raytek MX-4).

Description of the chambers and system

Ground areas of the six chambers follow a logarithmic scale with the diameter of the chambers doubling from 7.5 cm to 240 cm. The height of each chamber is 70 cm. The cylinder-jacket of the chambers has been arched from UV-B resistant water clean plexiglass. The air motion within the chambers is supplied by an outer fan except at the two largest chambers where the ventilation systems are within the chamber. The chambers are suited for measurements in closed system.

Description of the measurements

To analyse the stand photosynthetic activity at different scales we have measured 18 plots in the loess grassland, 20 plots in the sandy grassland and 9 plots in the ruderal weed association at each of the six scales with three replicate measurements in each plots.

Our study was carried out at the beginning and middle of June 2001 in case of *Salvio-Festucetum* and *Festucetum vaginatae danubiale* associations and in October in the *Convolvulo-Agropyretum* weed association. By this time plants in the *Salvio-Festucetum* community were fully developed and apparently not suffering from any kind stress. In contrast the *Festucetum vaginatae danubiale* stand showed the symptoms of severe drought stress.

344 stand physiological measurements were carried out in 120 plots in the *Salvio-Festucetum* association, 382 measurements in the 120 plots of the *Festucetum vaginatae danubiale* sandy grassland stand and further 162 in the 54 plots of *Convolvulo-Agropyretum* weed association.

Results and Discussion

In all of the three investigated vegetation the variability of CO₂-assimilation of the vegetation showed spatial scale-dependence. The lowest variability of the vegetation's photosynthesis was found at the smaller scales in the more organised loess and weed associations (Fig. 1), while at the less organised sand association the lowest variability was found at the largest scale (d = 240 cm). Variability was largest in the least organised sandy grassland. Presumably the spatial scale with the lowest variability can be considered the physiological minimal area (physiological unit of community). But this aspect and relationship between coenological (botanical composition) and physiological scale-dependence should be a matter of further detailed analysis.

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