Can plant community ordinations be affected by various sample plot sizes in grasslands?

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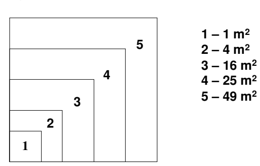
The size of sample plots played a key role during the development of methods in European phytosociology. Attempts to find correct plot size by seeking the minimal area, i.e. the smallest possible area that already contains the species of regular occurrence in the stand, did not bring satisfactory results. Therefore, appropriate plot sizes for various vegetation types were proposed by several authors in vegetation science textbooks, issued in the 1960s-1970s. This development resulted in a rough standardization of plot sizes for different vegetation types. However, the analysis of the size of plots stored in the Czech National Phytosociological Database (Table 1), reveals a considerable heterogeneity. Phytosociological databases in Europe contain hundreds of thousands of samples recorded in plots of various sizes during the last century. Little has been known about the effect of varying plot sizes on ordination, classification, and other analysis of vegetation plot data.

Table 1: Summary statistics of the plot sizes, that are stored in the Czech National Phytosociological Database. Plots sampled in 1970–2000 were chosen for the analysis. **N** – number of samples; **Mean** – mean plot size; **SD** – standard deviation of plot size; **V** – variation coefficient; **Min, Max** – minimum and maximum plot size found.

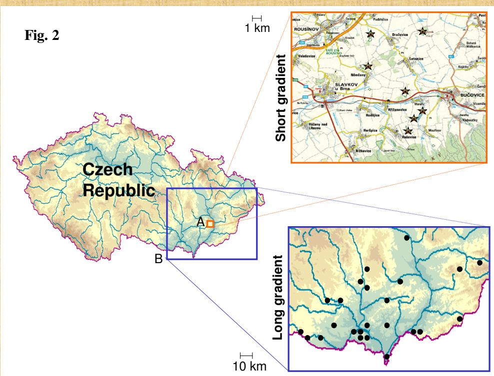
	N	Mean	SD	V	Most frequent plot sizes	Min	Max
Aquatic vegetation							
Lemnetea	547	28	41	1.4	25; 16; 100	1	400
Charetea fragilis	18	21	22	1.1	25; 16; 6	1	100
Potametea	1119	33	49	1.5	25; 16	1	900
Vegetation of fresh-water marches and fens							
Isoëto-Littorelletea	113	9	8	0.9	4; 9; 25	0.3	40
Isoëto-Nanojuncetea	244	13	15	1.2	25	0.2	100
Montio-Cardaminetea	290	13	23	1.8	9; 1	1	300
Phragmito-Magnocaricetea	3257	22	22	1.0	25; 16	0.6	400
Scheuchzerio-Caricetea fuscae	615	25	51	2.1	25; 16	0.1	900
Oxycocco-Sphagnetea	273	72	130	1.8	100; 25	0.2	1000
Chasmophytic vegetation							
Asplenietea trichomanis	212	6	5	0.9	4; 10; 5	0.2	30
Thlaspietea rotundifolii	69	12	6	0.5	10; 25	2	30
Arctic and alpine vegetation							
Juncetea trifidi	105	16	14	0.9	16; 25	0.1	100
Mulgedio-Aconitetea	440	26	26	1.0	25; 16	2	225
Synanthropic vegetation							
Bidentetea tripartiti	326	22	29	1.3	25; 16	2	400
Polygono arenastri-Poëtea annuae	1050	10	11	1.1	10; 2	0.5	100
Stellarietea mediae	1214	20	20	1.0	16; 20; 10	0.8	100
Artemisietea vulgaris	473	15	12	0.8	10; 20	1	100
Galio-Urticetea	1282	18	26	1.4	10; 20; 25; 15; 16	1	400
Epilobietea angustifolii	453	37	30	0.8	25	0.3	300
Temperate heathlands and grasslands							
Calluno-Ulicetea	892	22	17	0.8	16; 25	0.3	200
Koelerio-Corynephoretea	399	11	12	1.1	25; 2; 1; 16	1	100
Molinio-Arrhenatheretea	4965	21	22	1.1	25; 16	1	400
Trifolio-Geranietea	219	28	33	1.2	25	2	300
Festuco-Brometea	3127	24	19	0.8	25; 16	0.1	300
Puccinellio-Salicornietea	8	8	8	1.0	2; 8	1	25
Temperate and boreal woodlands and scrub							
Rhamno-Prunetea	134	52	57	1.1	100	0.5	400
Salicetea purpureae	111	180	87	0.5	200; 150; 100; 300; 250	25	400
Alnetea glutinosae	180	174	114	0.7	100; 225; 200	4	625
Querco-Fagetea	4337	284	135	0.5	400; 200; 300; 100	1	2500
Erico-Pinetea	19	184	47	0.3	200; 100	100	300
Vaccinio-Piceetea	918	200	158	0.8	100; 400; 25	4	1600

Fig. 1



Data from nested plots of increasing size, placed along two ecological gradients, were used to investigate the effect of sample plot size. The range of sizes was selected so as to include the sizes commonly used for sampling in European phytosociology.

Fig. 2



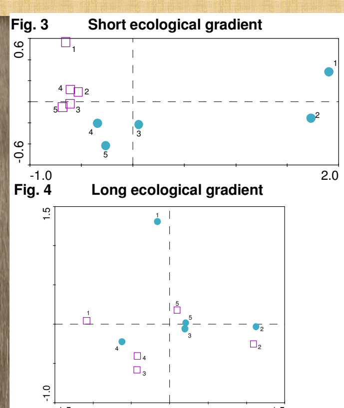
In order to compare the effect of plot size in homogeneous and heterogeneous data sets, series of samples of vegetation types were collected separately along a short and a long ecological gradient. The short gradient was sampled in dry grasslands dominated by *Carex humilis* and *Brachypodium pinnatum* in nature reserves close to the town of Slavkov (Austerlitz; Fig. 2A) in the southeastern Czech Republic. The long gradient was sampled in various grasslands of dry, mesic, and wet habitats across a wider geographical area of southern Moravia, the southeastern Czech Republic (Fig. 2B).

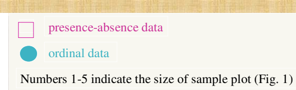
Ordinations of subsets of plots of the same size were performed separately for each ecological gradient. Two different transformations of species percentage cover (ordinal and presence-absence) were used in order to compare the effect of plot size and gradient length with the effect of transformation. PCA ordinations were done for samples from the short ecological gradient and DCA ordinations for samples from the long ecological gradient. The resulting ordinations were compared with Procrustean analysis using PROTEST program. Procrustean analysis attempts to match different configurations of plots from the same site in particular ordinations through rotation and dilatation. Permutation procedure in PROTEST assesses the statistical significance of Procrustean fit. The results (statistic measure m_{12}) of Procrustean analysis were used for creating the distance matrix, which was subjected to principal coordinate analysis (PCoA). The PCoA enables to visually examine concordance between ordinations based on different plot sizes and to evaluate differences, caused by data transformation (Figs. 3 and 4).

Ordinations of samples recorded in different plot sizes often appear in various studies. Therefore, samples from different plot sizes were chosen in order to compare ordinations containing samples with various plot size. Two size ranges were compared: (1) size of 16 and 25 m², i. e. plots of similar size that are the most commonly used in the field work (Figs. 5 and 6 A, B) and (2) size of 1 and 49 m², i. e. plots with the largest differernce in size (Figs. 5 and 6 C, D).

Fig. 3 Short ecological gradient

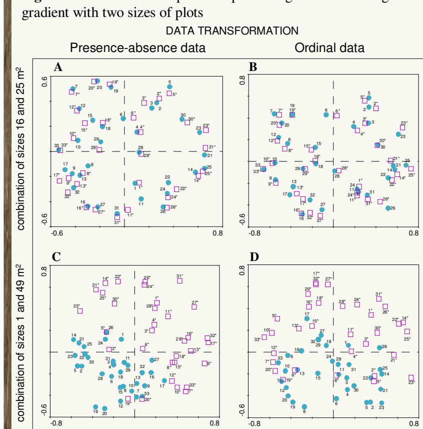
Fig. 4 Long ecological gradient





The plot size had a strong effect in both ecological gradients and also in both data transformations. The smallest plot sizes (1 and 4 m²) showed the most deviating patterns in both ordinations, while samples from larger sizes gave similar results. The transformation of percentage cover also affected the results, more so when samples were collected along the short ecological gradient (Fig. 3). Ordinations of data from the long ecological gradient show similar results with both data transformations (Fig. 4), but the main factor responsible for the differences in ordinations is the plot size.

Fig. 5 PCA ordinations of plots sampled along the short ecological gradient with two sizes of plots



Short ecologigal gradient

Different sizes of plots affected the resulting pattern of ordination in data sets sampled along the short ecological gradient regardless transformation used (Fig. 5). Pairs of plots with the largest difference in size in a series were clearly separated in the ordination space (Figs. 5 C, D).

Ordinations of plots with similar size were not influenced by the different size of plots so much, even though some of pairs of plots in a series were separated from each other in ordination (Figs. 5 A, B).

Long ecologigal gradient

Neither different plot size nor data transformation had any influence on ordination pattern in data sets sampled along the long ecological gradient (Fig. 6). Using the largest difference in size, some of pairs of plots in a series are separated from each other (Figs. 6 C, D) but it does not influence the ordination patterns.

Data transformation seems to have no influence on the ordination pattern along both short and long ecological gradient.

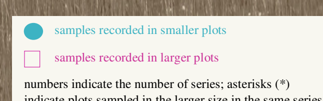
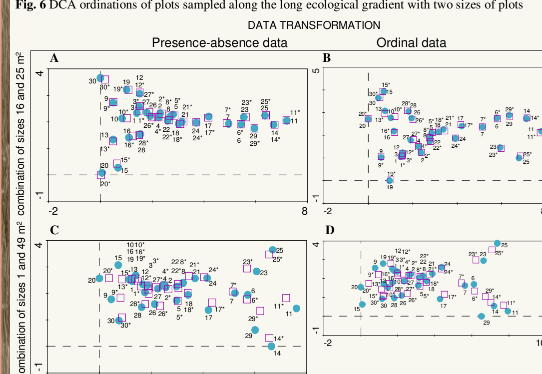


Fig. 6 DCA ordinations of plots sampled along the long ecological gradient with two sizes of plots



Samples of various size stored in phytosociological databases should be carefully selected before analysis. This study shows that samples recorded in too small plots could strongly affect ordination results regardless of transformation used. Samples recorded in large plots produce ordination results less affected by the plot size. Samples differing in size by one order (e.g., 1 and 49 m²) seem to be inappropriate to combine together in ordination analysis, especially when they were sampled along a short ecological gradient.