

Different aspects of plant diversity show contrasting patterns in Carpathian forest openings

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Abstract It has long been known that α - and β -diversity are driven by different ecological processes. Recently, several theoretical papers have suggested that β -diversity can be expressed in many different ways, and that these measures might have different meanings and behaviours. In terms of ecological understanding, it is important to test how these diversity measures behave in different settings, yet this has been rarely attempted. We investigated this question using forest openings in the Trascău Mountains, Romania, which contain species from grasslands of high nature value. The sampling was conducted in 40 openings, using edge-to-interior transects composed of 1-m² plots (α -diversity), from which we calculated five β -diversity measures at transect level. As predictor variables, we used canopy openness (from hemispherical photos), tree litter cover, heat

load index, altitude, and bedrock type for α -diversity, and the means and ranges of these for β -diversity. Generalized linear mixed models showed that α -diversity was mostly explained by the first two variables. Amongst the β -diversity measures, the classical additive and multiplicative measures differed, the latter being similar to the Sørensen-based multiple-site dissimilarity. None of the predictors explained the slope of distance decay or Simpson-based multiple-site dissimilarity, except when considering ecological subsets of the species. We discuss the possible ecological processes underlying the different results, and the implication of our findings for nature conservation in the region. In conclusion, we support the joint application of different measures of α - and β -diversity, as long as their particular properties are taken into account.

Keywords α -diversity · Apuseni Mountains · β -diversity · Biodiversity · Diversity–environment relationship · Multiple-site dissimilarity

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Introduction

Measuring biodiversity is of central importance for both conservation and scientific purposes (Humphries et al. 1995; Purvis and Hector 2000), and species richness is considered the central ‘currency’ of biodiversity (Gaston and Spicer 2004). In general, three major spatial components of species diversity

that describe different facets of communities or ecosystems have been recognized: α -diversity (local), β -diversity (differentiation) and γ -diversity (regional) (Whittaker 1956; van der Maarel 1997; Koleff et al. 2003; Magurran 2004; Jurasinski et al. 2009).

Many studies in ecology have used α -diversity measures for comparing different treatments or sites (e.g. Bruun et al. 2003; Pereira et al. 2007; Bailey et al. 2010; Schultz et al. 2011). However, analysing α -diversity alone neglects the relevance of β -diversity on the regional diversity (γ -diversity) (Clough et al. 2007; Tuomisto 2010a, b). Moreover, since the different diversity components inform about different ecological processes, conservation strategies based upon a single measurement are not recommended (Rodríguez-Zaragoza and Arias-González 2008). Thus, in order to achieve a more comprehensive knowledge of the different aspects of the biodiversity of a system or region, both α - and β -diversity should be examined (e.g. Burnham 2004; Dengler 2009; Mandl et al. 2010).

Recently, several theoretical papers have suggested that β -diversity can be expressed in many different ways (Baselga et al. 2007; Jurasinski et al. 2009; Tuomisto 2010a, b), and that these measures might have different meanings and behaviours (Koleff et al. 2003; Baselga 2010b; Anderson et al. 2011). In order to gain a better understanding, it is important to test how these diversity parameters behave in particular ecological settings. Given that such comparative studies have rarely been carried out so far, this became the aim of our current investigation, using as a model system forest openings, which are known to promote high species diversity (Schnitzer and Carson 2001; Eysenrode et al. 2002; Schumann et al. 2003). The α -diversity in forest openings is affected by changes in certain environmental variables (e.g. light, temperature) at the time of their creation (Zhao et al. 2006) and by a continuous process of species immigration from the surrounding forests. Likewise, β -diversity within an opening is expected to be high over relatively short distances due to a steep gradient in the availability of resources such as light (Brokaw and Busing 2000). Measuring different components of diversity in forest openings may not only improve scientific knowledge, but also help conservation planning by providing insights into which structural features contribute to high biodiversity at a landscape scale.

In addition to explaining α -diversity at a fine scale by means of several environmental variables, our aim

was to compare the responses of a suite of distinct β -diversity measures to the means and ranges of the same variables. For the latter, we chose two widely used classical measures, namely *additive β -diversity* (β_{Add} ; Lande 1996) and *multiplicative β -diversity* (β_{Mult} ; Whittaker 1960). Then, in order to take into account species composition, we also employed three multivariate β -diversity measures. The first of these calculates β -diversity as the *slope of the distance decay relationship* (Nekola and White 1999), accounting for the distance effect on compositional variation. Such measures have been criticized for the lack of independence between pairwise dissimilarities (due to the repetition of samples in several pairs; Diserud and Ødegaard 2007), and so we additionally computed the *Sørensen-based multiple-site dissimilarity* (β_{SOR} ; Baselga 2010b). Multiple-site measures make use of information on species shared by more than two sites (Diserud and Ødegaard 2007). This is, however, a broad-sense β -diversity measure, because it gives information on both nestedness and turnover in the data (Baselga 2010b). Communities that are characterized by pure nestedness have sites containing subsets of species from the richer sites, whereas those defined by turnover have exclusive species. These correspond to the processes of species gain (or loss) and species replacement, respectively (Baselga 2010b). In order to see whether a narrow-sense measure of pure spatial turnover is appropriate in this context, we employed the *Simpson-based multiple-site dissimilarity* (β_{SIM} ; Baselga et al. 2007). It is important to distinguish turnover because it is relevant to particular ecological processes such as niche segregation. Of the chosen β -diversity measures, β_{Add} , β_{Mult} and one corresponding to our β_{SIM} (Lennon et al. 2001) have been recommended by Gaston et al. (2007) to be used jointly.

We chose the Trascău Mountains (part of the Apuseni Mountain range, Romanian Carpathians) for this study since forest openings of different size are frequent there. 'Forest opening' was used as a generic term both for 'gaps' (small, created through elimination of one or two tree individuals; Watt 1947) and for 'clearings' (bigger, originating from major disturbances such as clear-cuttings; Forman 1995). The openings of the area mainly originate from local, sporadic tree logging and are maintained over time by light grazing by cattle or occasionally deer. Extensive grazing, particularly in the vicinity of isolated

mountain villages, has been a dominant method of grassland management for many centuries throughout Romania (Cremene et al. 2005) and particularly in the Trascău Mountains (Başnou et al. 2009), where free grazing works to extend grassy vegetation into the patches of open forest and to slow tree regeneration. In the future, traditional land uses in the Trascău Mountains are expected to become more restricted due to agricultural intensification. This is being driven by the Common Agricultural Policy (CAP) of the European Union, with potentially significant impacts on biodiversity (Young et al. 2007). The vegetation of the forest openings contains a high proportion of species from grasslands of high nature value (as described by Brinkmann et al. (2009) for the Apuseni Mountains) and forest edge species, of which many are red-listed in Central Europe (Korneck et al. 1998). We therefore assume that the forest openings of the Trascău Mountains might play an important role for the maintenance of these two species categories in the future.

In this study, we address the following questions using the forest openings of the Trascău Mountains as a model system: (i) Which environmental variables drive α -diversity at a fine scale (1 m²)? (ii) How are different measures of β -diversity influenced by environmental factors? (iii) Could the different observed patterns of the diversity measures that we compared be explained by ecological processes and/or mathematical constraints?

Materials and methods

Study area

The study was conducted in the Trascău Mountains (46°16'N and 23°28'E), a part of the Apuseni Mountain range that belongs to the south-eastern Carpathians, Romania (Fig. 1). Altitude varies between approximately 400 m a.s.l. in valleys (e.g. Arieş, Hăşdate, Ampoi) and 1,369 m a.s.l. at the peak of Dângău. The majority of the area is below 1,000 m a.s.l. For a geographical unit of relatively low altitude, the relief can be remarkably sharp. The climate is temperate continental. Due to the altitudinal differences, mean daily temperatures range from –6 to –3°C in January, and from 14 to 18°C in July (Măhăra and Popescu-Argeşel 1993). Mean annual precipitation decreases

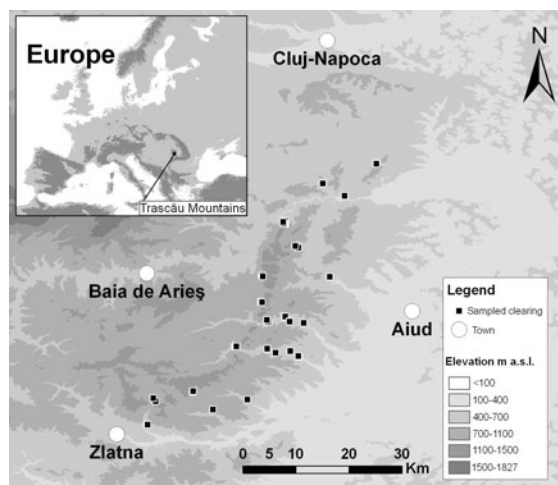


Fig. 1 Location of the sampled forest openings in the Trascău Mountains (Romanian Carpathians)

gradually from about 1,000 mm at high elevations to 700–800 mm at the eastern margin of the mountains towards the Transylvanian Plain (Măhăra and Popescu-Argeşel 1993). The bedrock consists of ophiolites, flysch, crystalline schists, as well as limestones (Popescu 1977).

The landscape is dominated by a mosaic of broad-leaved forests, secondary meadows, and calcareous grasslands. According to Bohn et al. (2004), the potential natural vegetation is represented by south-eastern Carpathian hornbeam forests (*Fagus sylvatica* and *Carpinus betulus* with *Melampyrum bihariense*; mapping unit F126) and pre-Carpathian beech forests (*F. sylvatica* and sometimes *C. betulus* and/or *Abies alba* in the tree layer, with *Cardamine glanduligera*, *Symphytum tuberosum* and sometimes *S. cordatum* in the herb layer; mapping unit F125). Grasslands are a common feature in this area, mostly being mesophilous or xero-mesophilous types (Gergely 1964; Şuteu 1970). The dominant grasses include *Agrostis tenuis*, *Anthoxanthum odoratum*, *Festuca rubra*, and *Festuca rupicola*. The grasslands are secondary and used for grazing and hand mowing (Başnou et al. 2009). Despite the several phytosociological studies of the area, the forest openings have not been investigated before, even though they are frequent throughout the Trascău Mountains. These openings are mostly dominated by grassland, forest edge and forest herbaceous species because low-intensity grazing by cattle and deer inhibits the re-establishment of trees.

Field sampling

The field sampling was carried out from May to the first half of August 2010. We sampled the vegetation in 40 forest openings of different sizes, ranging from approximately 15 to 50 m width. The openings were chosen to be representative of the study area in terms of spatial distribution and predominant environmental conditions (bedrock type and aspect) (Fig. 1). In each opening, a transect was laid out, from the highest point towards and sometimes beyond the centre (i.e. in a down-slope orientation, sensu Alignier and Deconchat 2011). Transect sampling was employed to encompass the range of conditions to be found in the interior of the forest openings. In order to reduce confounding variables, we excluded from this study openings that showed fresh tree stumps, dense regeneration of tree species, physical disturbances (i.e. roads, digging by boars, heavy grazing) or dissection by streams.

Each transect consisted of four square plots of 1 m², arranged at 3-m intervals. The first plot was placed under the last tree branches at the top edge of the opening. For each of the total of 160 plots, all rooted vascular plant species were recorded. Young and other problematic specimens were identified at the level of genus (i.e. *Viola*, *Rubus*, *Carduus*). The plant nomenclature follows the online version of 'Flora Europaea' (Royal Botanic Garden Edinburgh 2011).

At the transect level, we recorded three environmental variables (Table 1): *Altitude* was measured in the field using a GPS receiver (Garmin GPS 60); *Bedrock type* was coded based on field observations as A or B, corresponding to acid (ophiolites, crystalline schists) or basic substrates (limestones), respectively; and *Aspect* was assessed using a standard compass.

For each 1-m² plot, the following four environmental variables were recorded (Table 1), selected to be representative of both abiotic and biotic conditions. *Slope* was measured in degrees, using an inclinometer. *Heat load index* was calculated based on equation 1 provided by McCune and Dylan (2002), having the highest values on south–west slopes and lowest values on north–east slopes (theoretical range 0.03–1.11). *Cover of tree litter* was estimated visually in percent. Finally, *canopy openness* was assessed by taking near-hemispherical photos with a Nikon D40 digital camera equipped with a 18 mm standard lens and a wide angle converter lens (0.42×). We imported the photos into

Table 1 Descriptive statistics for the environmental variables measured at the transect level ($n = 40$) and at the 1-m² plot level ($n = 160$)

	Mean	SD	Minimum	Maximum
<i>Transect</i>				
Altitude (m a.s.l.)	716	213	442	1,156
Bedrock	acid (24), basic (16)			
Aspect	N (7), S (10), E (3), W (1), NE (3), NW (2), SE (6), SW (8)			
<i>Plot</i>				
Canopy openness (%)	48	26	4	97
Tree litter cover (%)	43	34	0	100
Slope (°)	19	7	0	35
Heat load index	0.74	0.17	0.27	1.00

For the categorical variables, the number of transects of each class is given in brackets

SD Standard deviation

the software Gap Light Analyser version 2 (Frazer et al. 1999) and extracted percentages of open sky.

Data analysis

We classified the species into three categories: (1) meadow, (2) forest edge, and (3) forest species (see Electronic Online Resource 1). This was based on the phytosociological classes given by Ellenberg et al. (1991), complemented by the habitat descriptions in the Romanian flora of Ciocârlan (2009) for species not covered by the above or where the assigned class was questionable in the context of our geographic region. An additional list comprised species that were not assigned to any of these three categories (i.e. pioneers, ruderals and taxa identified at the genus level).

Multi-collinearity between the environmental variables was checked by calculating pairwise Pearson correlations. We considered two variables as collinear when $|r| > 0.7$.

As a measure for α -diversity, we took species richness at the 1-m² scale, both for the total species list and for grassland, forest edge and forest species separately. To model these α -diversities, we included the environmental variables measured at the plot scale as predictors. Since we dealt with count data for the α -diversity, we assumed Poisson distribution of errors.

Moreover, we tested the α -diversity for overdispersion, using the index of dispersion $D = \frac{\text{Observed variance}}{\text{Theoretical variance}} \times (\text{Number of observations} - 1)$ (Pielou 1977) and compared it to a Chi-square distribution with $(\text{Number of observations} - 1)$ degrees of freedom (Scrucca 2010). If overdispersion was detected ($P < 0.05$), we used models with negative binomial instead of Poisson distribution of errors.

As the plots were nested within the transects, spatial autocorrelation potentially existed. Thus, we employed generalized linear mixed models (GLMMs), as they are able to account for nested samples (Zuur et al. 2009; Tokuoka et al. 2010). The transect identity was included as a random factor. We chose this approach instead of linear mixed models (LMM) because we were dealing with count data.

The classical additive (β_{Add}) and multiplicative (β_{Mult}) measures of β -diversity were calculated with the respective formulas: $\beta_{\text{Add}} = \gamma - \bar{\alpha}$ (Lande 1996) and $\beta_{\text{Mult}} = \frac{\gamma}{\bar{\alpha}}$ (Whittaker 1960). The cumulative number of species from the four plots was used as a proxy for the γ -diversity of the respective forest opening, and $\bar{\alpha}$ was the mean species richness per plot. In order to compute the β -diversity as the slope of the distance decay relationship (Nekola and White 1999) in linear representation, we used pairwise Bray–Curtis dissimilarities and distances between plots. Sørensen-based (β_{SOR}) and Simpson-based (β_{SIM}) multiple-site dissimilarities were calculated using the formulas as follows:

$$\beta_{\text{SOR}} = \frac{\left[\sum_{i < j} \min(b_{ij}, b_{ji}) \right] + \left[\sum_{i < j} \max(b_{ij}, b_{ji}) \right]}{2 \left[\sum_i S_i - S_T \right] + \left[\sum_{i < j} \min(b_{ij}, b_{ji}) \right] + \left[\sum_{i < j} \max(b_{ij}, b_{ji}) \right]} \text{ and}$$

$$\beta_{\text{SIM}} = \frac{\left[\sum_{i < j} \min(b_{ij}, b_{ji}) \right]}{\left[\sum_i S_i - S_T \right] + \left[\sum_{i < j} \min(b_{ij}, b_{ji}) \right]}, \text{ where } S_i \text{ is the}$$

total number of species in site i , S_T is the total number of species in all sites considered together, and b_{ij} , b_{ji} are the number of species exclusive to sites i and j , respectively, when compared by pairs (Baselga 2010b). Finally, we modelled the relationships between the β -diversity measures and the means and ranges of the environmental variables at the transect level, through simple and multiple linear regressions. Multi-collinearity between the environmental variables was checked by the approach used for α -diversity variables.

To obtain the final models for both α - and β -diversity, a backward selection procedure was used. We successively dropped the least significant variable from the full model until only significant variables remained. The statistical computations were done in R (R Development Core Team 2011). We used the ‘s20x’ package (Balemi et al. 2011) for the pairwise correlations of environmental variables, ‘glmmADMB’ (Skaug et al. 2006) for the implementation of the generalized linear mixed models, ‘qcc’ (Scrucca 2010) for the overdispersion tests, and ‘vegan’ (Oksanen et al. 2011) for Bray–Curtis dissimilarity. The two multiple-site dissimilarities were calculated using the scripts provided by Baselga (2010b).

Results

The total number of vascular plants recorded was 258, of which 113 were classified as grassland, 58 as forest, and 58 as edge species, whilst 29 species remained unclassified (see Online Resource 1). The mean species richness per 1 m² was 17.2, including 8.3 grassland species, 4.3 edge species, and 2.5 forest species.

The pairwise correlations between the environmental variables revealed no collinear variables (maximum correlation occurred between canopy openness and tree litter cover: $r = -0.65$). Overdispersion was detected in the case of total ($D = 225.6$; $P < 0.01$), grassland ($D = 405.3$; $P < 0.01$), and forest species richness ($D = 241.5$; $P < 0.01$), but not for edge species richness ($D = 169.8$; $P = 0.26$). In the first three cases we ran GLMMs with negative binomial distribution and for the last one a GLMM with Poisson distribution. The α -diversity of total species richness was positively related to canopy openness and negatively to tree litter cover (Table 2). Grassland species richness was also positively associated with canopy openness, but had a negative relationship with tree litter cover and slope. The forest species richness was negatively related to canopy openness and heat load index (Table 2). For the richness of edge species, no environmental variables had significant influence.

The pairwise correlation analysis for the environmental variables to be used in the β -diversity models revealed a high correlation between canopy openness range and mean ($r = 0.72$) and between the ranges of

Table 2 Minimum adequate models, resulting from a backward elimination procedure, for predicting α -diversity (GLMMs, $n = 160$) and β -diversity (simple and multiple linear regressions, $n = 40$)

Diversity measure	Species group	Average (\pm SD)	Fixed effect	Std. coef.	SE	<i>P</i> value	R^2_{adj}	<i>F</i>
Species richness (1 m ²) (α)	Total	17.17 (\pm 4.94)	Canopy openness	0.146	0.055	0.007		
			Tree litter cover	-0.118	0.038	0.002		
	Grassland species	8.28 (\pm 4.59)	Canopy openness	0.412	0.084	<0.001		
			Tree litter cover	-0.277	0.110	0.012		
			Slope	-0.254	0.060	<0.001		
	Forest species	2.53 (\pm 1.96)	Heat load index	-0.729	0.342	0.033		
			Canopy openness	-0.700	0.112	<0.001		
	Additive (β_{Add})	Total	20.03 (\pm 4.88)	–				
Grassland species		9.90 (\pm 3.86)	Canopy openness range	0.452	0.038	0.003	0.184	9.778
Forest species		3.30 (\pm 1.67)	Canopy openness range	0.614	0.027	<0.001	0.361	23.040
Edge species		4.50 (\pm 1.80)	Altitude	0.332	0.001	0.037	0.087	4.698
Multiplicative (β_{Mult})	Total	2.17 (\pm 0.21)	–					
	Grassland species	2.29 (\pm 0.45)	Altitude	0.330	0.000	0.037	0.086	4.656
			Tree litter cover mean	0.404	0.003	0.005	0.280	8.597
	Forest species	2.52 (\pm 0.73)	Heat load index mean	-0.377	0.371	0.009		
			Canopy openness range	0.504	0.006	0.002	0.241	7.199
Edge species	2.10 (\pm 0.37)	Tree litter cover range	-0.393	0.005	0.011			
Slope of the distance decay ($\beta_{distance\ decay}$)	Total	0.02 (\pm 0.01)	–				0.087	4.724
	Grassland species	0.02 (\pm 0.02)	Heat load index range	0.333	0.051	0.036		
	Forest species	0.00 (\pm 0.03)	–					
	Edge species	0.02 (\pm 0.02)	–					
Sørensen-based multiple-site (β_{SOR})	Total	0.64 (\pm 0.05)	–					
	Grassland species	0.67 (\pm 0.10)	Canopy openness range	0.322	0.000	0.043	0.080	4.389
			Tree litter cover mean	0.389	0.001	0.007	0.259	7.819
	Forest species	0.69 (\pm 0.17)	Heat load index mean	-0.346	0.083	0.014		
			Canopy openness range	0.572	0.001	0.001	0.270	8.196
Edge species	0.62 (\pm 0.10)	Tree litter cover range	-0.418	0.001	0.010			
Simpson-based multiple-site (β_{SIM})	Total	0.57 (\pm 0.07)	–					
	Grassland species	0.51 (\pm 0.11)	–					
	Forest species	0.45 (\pm 0.27)	Tree litter cover range	-0.333	0.002	0.043	0.084	4.414
	Edge species	0.47 (\pm 0.17)	–					

The predictors included in the full models for α -diversity were: canopy openness, tree litter cover, slope, and heat load index. For β -diversity, we included means and ranges of the same predictors as at the transect level, plus bedrock type and altitude. In case of α -diversity, the opening identity always was treated as a random effect. Only significant predictors are shown, except canopy openness range for additive β -diversity. Std. coef. = standardized coefficients; SE = standard error

heat load index and slope ($r = 0.72$). In consequence, canopy openness range and heat load index range were selected as the more informative variables to be used in further analysis. The parameter β_{Add} for total and grassland species was positively associated with canopy openness range. For forest species, it had a

positive relationship with altitude (Table 2). β_{Mult} for total species was positively related to altitude, and it had a weak positive relationship with canopy openness range. For grassland species, it was associated positively with tree litter cover mean and negatively with heat load index mean. When calculated for forest

species, β_{Mult} was positively associated with canopy openness range and negatively with tree litter cover range. None of the predictors explained $\beta_{\text{distance decay}}$, except for grassland species, where it had a positive relationship with heat load index. β_{SOR} yielded similar results with β_{Mult} , except for total species, where it was significantly and positively influenced only by canopy openness range. β_{SIM} was positively related with tree litter cover, but only when calculated for forest species (Table 2). From the parameters of the full model, slope mean and bedrock type were not included in the minimum adequate models for any of the β -diversity parameters.

Discussion

The detected positive effect of canopy openness on the total α -diversity at the 1-m² scale indicates that species richness was higher towards the centre of the openings, probably due to a positive effect of increasing light intensity. Such a positive relationship between light and species diversity has also been reported in other studies that considered the opening size as a surrogate for light intensity (e.g. Anderson and Leopold 2002; Gálhidy et al. 2006). The negative relationship between the total α -diversity and tree litter cover can be explained by inhibitory influences of litter on plant regeneration, such as the mechanical resistance imposed on seedling establishment (Foster and Katherine 1998; Dupuy and Chazdon 2008). Nevertheless, it has been shown that some herbaceous species of woodland floors can be relatively insensitive to tree leaf litter (e.g. Sydes and Grime 1981). The positive relationship between canopy openness and the grassland species diversity reveals how the vegetation resembles grasslands towards the centre the study site. Albeit less evidently, the richness in grassland species was negatively related to slope, probably due to a more suitable water regime for the species on gentle slopes. Little attention has been directed to the effects of microtopography on biodiversity in forest openings (e.g. Barik et al. 1992; Anderson and Leopold 2002). The differentiation between species groups with respect to their response to habitat conditions in forest openings could be explained by their morphological and physiological acclimation potential (Popma and Bongers 1988). The lack of relationships between the edge species richness and the environmental variables

considered here suggests that—unlike for grassland and forest species—either they are within the openings not restricted by any of the environmental factors or two opposing factors levelled each other out. The boundaries of the edge species might be discernible only when considering either a larger range of ecological conditions (e.g. by including the adjacent forest floor; Dierschke 1974; Eisenberg et al. 2003), demography parameters, or morphology details (Crawford 2008). On the contrary, the forest species richness increased in plots with low canopy openness. We could include them in the category of understory specialists, which according to Denslow (1980) do not require forest openings for germination and growth. Interestingly, the heat load index had a stronger negative influence on the number of forest species than the canopy openness. This may be attributed to the lower tolerance of forest species in the open areas located on southern slopes.

To our knowledge, there has been no previous research dealing with β -diversity inside forest openings. Instead, β -diversity amongst forest openings has been analysed by some authors (e.g. Barik et al. 1992). In our study, a clear distinction first occurred between β_{Add} and β_{Mult} , presumably due to the inclusion/exclusion of joint absences in their calculation. This was in accordance with the results of Anderson et al. (2011), who found differences between the responses of these two measures in a comparative study dealing with the disturbance of coral reef communities over time. In the case of forest openings, the exclusion of joint absences is more appropriate when calculating β -diversity because samples at the extremes of their edge-to-interior environmental gradients must not be considered more similar because they lack species contained in between (Anderson et al. 2011). Thus, the information provided by β_{Mult} was more meaningful here, especially as β_{Add} has been criticized for its dependence on species richness (Jost 2007; Zeleny 2009; Baselga 2010a; Veech and Crist 2010). However, this fundamental criticism might be unjustified (Ricotta 2005), and the joint application of β_{Add} with other β -diversity measures is thus recommended (see also Anderson et al. 2011).

The incorporation of distance in the $\beta_{\text{distance decay}}$ calculation provided an explanation for its different behaviour in comparison with β_{SOR} ; they had been expected to give similar results because both are based on essentially the same dissimilarity measure

(Sørensen is equivalent to Bray–Curtis for presence–absence data). Since many of our transects crossed small openings, having similar values of environmental variables at the edges, the weak response of $\beta_{\text{distance decay}}$ to the predictors was not surprising. Moreover, as dispersal limitations hardly exist, $\beta_{\text{distance decay}}$ was unsuitable in this type of ecological setting. On the contrary, species variation is more likely to be driven here by changes in environmental conditions at fine scales. β_{SOR} has been known to have a linear relationship with β_{Mult} (Diserud and Ødegaard 2007; Baselga 2010b), so their similar response to the predictors was not surprising. β_{SOR} indicated the existence of a combination of nestedness and turnover in the data. Furthermore, as none of the predictors explained the narrow-sense β_{SIM} , except tree litter cover range in the case of forest species, we might conclude that pure spatial turnover is likely to be weak in the forest opening communities that we studied. Nonetheless, the calculation of β_{SIM} proved to be informative, as the rest of the measures were not able to test for pure species replacement.

Our study was not intended to provide a general consensus regarding which β -diversity measures should be used; however, it brings insights into their varying capabilities to discern patterns of community composition. Basically, we agree with Gaston et al. (2007) and Anderson et al. (2011) that the joint use of a range of β -diversity metrics that quantify complementary components of the spatial species turnover is the most promising approach.

Disentangling causal factors influencing α - and β -diversity patterns in forest openings can have important conservation implications. In particular, we emphasize the need to preserve the habitat attributes that increase species richness and variation. Such small secondary vegetation patches could make a major contribution to the biodiversity of the whole landscape, especially as they host numerous non-forest species within forested areas (see Online Resource 1). Moreover, forest openings will become more and more important for the maintenance of forest edge specialists, which are numerous and contain a high proportion of endangered species (Korneck et al. 1998). To ensure that forest openings of moderate size can provide suitable habitats for such species in the future, conservation should support small-scale forestry practices. These should be applied instead of large-scale clear-cuttings, which currently neglect

conservation necessities. Furthermore, the restriction of free grazing would be counter-productive as the animals are needed both to disperse the non-forest species and to prevent tree regeneration. Accordingly, the importance of large herbivores for the biodiversity of forest ecosystems as a whole, including openings, requires consideration during forestry operations. We urge that the current grazing regime needs to be evaluated when forestry operations are applied, challenging as this might be. The examination of the environmental conditions that promote plant species diversity in forest openings is, however, a step in the right direction.

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Different aspects of plant diversity show contrasting patterns in Carpathian forest openings, Plant Ecology, Pavel Dan Turtureanu* and Jürgen Dengler; Department of Taxonomy and Ecology, Faculty of Biology and Geology, Babeş-Bolyai University, e-mail: turtureanud@gmail.com

Online Resource 1 Complete list of all vascular plant species found in the study with their constancy in the 160 1-m² plots, arranged according to decreasing constancy. For each species, its assignment to one of the four habitat categories grassland, edge, forest and unclassified together with the source for this assignment is given.

Constancy (%)	Species name	Habitat category	Source
51	<i>Fragaria vesca</i>	Edge	Ellenberg et al. 1992
47	<i>Achillea millefolium</i>	Grassland	Ellenberg et al. 1992
46	<i>Brachypodium sylvaticum</i>	Forest	Ellenberg et al. 1992
40	<i>Festuca rupicola</i>	Grassland	Ciocârlan 2009
39	<i>Pimpinella saxifraga</i>	Edge	Ellenberg et al. 1992
36	<i>Veronica chamaedrys</i>	Unclassified	Ellenberg et al. 1992
34	<i>Helianthemum nummularium</i>	Grassland	Ellenberg et al. 1992
31	<i>Centaurea phrygia</i>	Grassland	Ellenberg et al. 1992
31	<i>Teucrium chamaedrys</i>	Unclassified	Ellenberg et al. 1992
30	<i>Cruciata glabra</i>	Edge	Ellenberg et al. 1992
30	<i>Euphorbia cyparissias</i>	Grassland	Ellenberg et al. 1992
29	<i>Carex tomentosa</i>	Grassland	Ellenberg et al. 1992
29	<i>Clinopodium vulgare</i>	Edge	Ellenberg et al. 1992
29	<i>Thymus glabrescens</i> agg	Grassland	Ciocârlan 2009
28	<i>Agrostis capillaris</i>	Grassland	Ellenberg et al. 1992
28	<i>Chamaespartium sagittale</i>	Grassland	Ellenberg et al. 1992
28	<i>Hypericum maculatum</i>	Edge	Ellenberg et al. 1992
28	<i>Viola</i> sp.	Unclassified	-
27	<i>Plantago lanceolata</i>	Grassland	Ellenberg et al. 1992
26	<i>Lotus corniculatus</i>	Grassland	Ellenberg et al. 1992
25	<i>Galium verum</i>	Grassland	Ellenberg et al. 1992
22	<i>Dorycnium pentaphyllum</i> subsp. <i>herbaceum</i>	Edge	Ellenberg et al. 1992
21	<i>Medicago falcata</i>	Edge	Ellenberg et al. 1992
21	<i>Trifolium medium</i>	Edge	Ellenberg et al. 1992
20	<i>Festuca rubra</i>	Grassland	Ellenberg et al. 1992
20	<i>Leontodon hispidus</i>	Grassland	Ellenberg et al. 1992
20	<i>Trifolium pratense</i>	Grassland	Ellenberg et al. 1992
19	<i>Anthoxanthum odoratum</i>	Unclassified	Ellenberg et al. 1992
19	<i>Prunella vulgaris</i>	Grassland	Ellenberg et al. 1992
16	<i>Carex pallelescens</i>	Grassland	Ellenberg et al. 1992
16	<i>Luzula luzuloides</i>	Forest	Ellenberg et al. 1992
16	<i>Peucedanum oreoselinum</i>	Edge	Ellenberg et al. 1992
15	<i>Genista tinctoria</i>	Grassland	Ellenberg et al. 1992
14	<i>Coronilla varia</i>	Edge	Ellenberg et al. 1992
14	<i>Galium mollugo</i>	Grassland	Ellenberg et al. 1992
14	<i>Potentilla chrysantha</i>	Grassland	Ellenberg et al. 1992
14	<i>Potentilla erecta</i>	Grassland	Ellenberg et al. 1992
14	<i>Prunus spinosa</i>	Forest	Ellenberg et al. 1992

Constancy (%)	Species name	Habitat category	Source
14	<i>Ranunculus polyanthemos</i>	Grassland	Ellenberg et al. 1992
13	<i>Dactylis glomerata</i>	Unclassified	Ellenberg et al. 1992
13	<i>Hieracium pilosella</i>	Grassland	Ellenberg et al. 1992
13	<i>Rumex acetosa</i>	Grassland	Ellenberg et al. 1992
12	<i>Filipendula vulgaris</i>	Edge	Ciocârlan 2009
12	<i>Glecoma hirsuta</i>	Forest	Ciocârlan 2009
12	<i>Leucanthemum vulgare</i>	Grassland	Ellenberg et al. 1992
11	<i>Agrimonia eupatoria</i>	Edge	Ellenberg et al. 1992
11	<i>Astrantia major</i>	Unclassified	Ellenberg et al. 1992
11	<i>Carex montana</i>	Unclassified	Ellenberg et al. 1992
11	<i>Primula veris</i> subsp. <i>columnae</i>	Edge	Ciocârlan 2009
11	<i>Vicia tetrasperma</i>	Edge	Ellenberg et al. 1992
10	<i>Stellaria graminea</i>	Grassland	Ciocârlan 2009
10	<i>Trifolium ochroleucon</i>	Grassland	Ellenberg et al. 1992
9	<i>Briza media</i>	Grassland	Ellenberg et al. 1992
9	<i>Cornus sanguinea</i>	Forest	Ellenberg et al. 1992
9	<i>Crataegus monogyna</i>	Forest	Ellenberg et al. 1992
9	<i>Lembotropis nigricans</i>	Edge	Ellenberg et al. 1992
9	<i>Melampyrum bihariense</i>	Edge	Ciocârlan 2009
9	<i>Primula veris</i>	Unclassified	Ellenberg et al. 1992
9	<i>Rosa canina</i>	Forest	Ellenberg et al. 1992
8	<i>Acer campestre</i>	Forest	Ellenberg et al. 1992
8	<i>Asarum europaeum</i>	Forest	Ellenberg et al. 1992
8	<i>Asperula cynanchica</i>	Grassland	Ellenberg et al. 1992
8	<i>Cruciata laevipes</i>	Grassland	Ellenberg et al. 1992
8	<i>Fraxinus excelsior</i>	Forest	Ellenberg et al. 1992
8	<i>Hieracium sabaudum</i>	Forest	Ellenberg et al. 1992
8	<i>Knautia arvensis</i>	Grassland	Ellenberg et al. 1992
8	<i>Medicago minima</i>	Grassland	Ciocârlan 2009
8	<i>Poa compressa</i>	Grassland	Ellenberg et al. 1992
8	<i>Ranunculus cassubicus</i>	Edge	Ciocârlan 2009
8	<i>Salvia pratensis</i>	Grassland	Ellenberg et al. 1992
8	<i>Stachys officinalis</i>	Grassland	Ellenberg et al. 1992
8	<i>Taraxacum officinale</i>	Unclassified	Ellenberg et al. 1992
8	<i>Veronica officinalis</i>	Unclassified	Ellenberg et al. 1992
7	<i>Acer pseudoplatanus</i>	Forest	Ellenberg et al. 1992
7	<i>Verbascum nigrum</i>	Edge	Ellenberg et al. 1992
7	<i>Vicia sepium</i>	Unclassified	Ellenberg et al. 1992
6	<i>Campanula persicifolia</i>	Forest	Ellenberg et al. 1992
6	<i>Carex muricata</i> subsp. <i>lamprocarpa</i>	Edge	Ellenberg et al. 1992
6	<i>Danthonia decumbens</i>	Grassland	Ellenberg et al. 1992
6	<i>Dianthus carthusianorum</i>	Grassland	Ellenberg et al. 1992
6	<i>Festuca pratensis</i>	Grassland	Ellenberg et al. 1992
6	<i>Luzula campestris</i>	Grassland	Ellenberg et al. 1992
6	<i>Lysimachia vulgaris</i>	Unclassified	Ellenberg et al. 1992
6	<i>Polygala amara</i>	Grassland	Ellenberg et al. 1992
6	<i>Trifolium montanum</i>	Grassland	Ellenberg et al. 1992
5	<i>Geum urbanum</i>	Forest	Ellenberg et al. 1992
5	<i>Hepatica nobilis</i>	Forest	Ellenberg et al. 1992
5	<i>Prunus avium</i>	Forest	Ellenberg et al. 1992
5	<i>Scabiosa ochroleuca</i>	Grassland	Ellenberg et al. 1992
4	<i>Alchemilla vulgaris</i>	Grassland	Ellenberg et al. 1992
4	<i>Campanula rapunculoides</i>	Edge	Ellenberg et al. 1992
4	<i>Carduus</i> sp.	Unclassified	-
4	<i>Chamaecytisus albus</i>	Edge	Ciocârlan 2009
4	<i>Dichantium ischaemum</i>	Grassland	Ellenberg et al. 1992

Constancy (%)	Species name	Habitat category	Source
4	<i>Elymus hispidus</i>	Grassland	Ellenberg et al. 1992
4	<i>Euphorbia amygdaloides</i>	Forest	Ellenberg et al. 1992
4	<i>Ferulago sylvatica</i>	Edge	Ciocârlan 2009
4	<i>Galium album</i> subsp. <i>album</i>	Grassland	Ellenberg et al. 1992
4	<i>Gentiana asclepiadea</i>	Edge	Ellenberg et al. 1992
4	<i>Hieracium praealtum</i> subsp. <i>bauhinii</i>	Grassland	Ellenberg et al. 1992
4	<i>Lathyrus hallersteinii</i>	Edge	Ciocârlan 2009
4	<i>Ligustrum vulgare</i>	Forest	Ellenberg et al. 1992
4	<i>Mercurialis perennis</i>	Forest	Ellenberg et al. 1992
4	<i>Origanum vulgare</i>	Edge	Ellenberg et al. 1992
4	<i>Oxalis acetosella</i>	Forest	Ciocârlan 2009
4	<i>Pulmonaria officinalis</i>	Forest	Ellenberg et al. 1992
4	<i>Seseli gracile</i>	Grassland	Ciocârlan 2009
4	<i>Tanacetum corymbosum</i>	Forest	Ellenberg et al. 1992
4	<i>Trifolium repens</i>	Grassland	Ellenberg et al. 1992
4	<i>Veronica urticifolia</i>	Forest	Ellenberg et al. 1992
4	<i>Vincetoxicum hirsundinaria</i>	Edge	Ellenberg et al. 1992
3	<i>Ajuga reptans</i>	Unclassified	Ellenberg et al. 1992
3	<i>Allium flavum</i>	Grassland	Ciocârlan 2009
3	<i>Arabis hirsuta</i>	Grassland	Ellenberg et al. 1992
3	<i>Aster amellus</i>	Edge	Ellenberg et al. 1992
3	<i>Carex depressa</i> subsp. <i>transsilvanica</i>	Edge	Ciocârlan 2009
3	<i>Carex humilis</i>	Grassland	Ellenberg et al. 1992
3	<i>Centaurea micranthos</i>	Grassland	Ciocârlan 2009
3	<i>Cephalaria radiata</i>	Grassland	Ciocârlan 2009
3	<i>Chamaecytisus hirsutus</i>	Grassland	Ellenberg et al. 1992
3	<i>Clematis vitalba</i>	Forest	Ellenberg et al. 1992
3	<i>Corylus avellana</i>	Forest	Ellenberg et al. 1992
3	<i>Digitalis grandiflora</i>	Edge	Ellenberg et al. 1992
3	<i>Euphorbia polychroma</i>	Edge	Ellenberg et al. 1992
3	<i>Festuca heterophylla</i>	Forest	Ellenberg et al. 1992
3	<i>Fraxinus ornus</i>	Forest	Ellenberg et al. 1992
3	<i>Geranium phaeum</i>	Edge	Ellenberg et al. 1992
3	<i>Geranium robertianum</i>	Forest	Ciocârlan 2009
3	<i>Hieracium bifidum</i>	Forest	Ellenberg et al. 1992
3	<i>Inula ensifolia</i>	Edge	Ciocârlan 2009
3	<i>Koeleria macrantha</i>	Grassland	Ellenberg et al. 1992
3	<i>Lathyrus niger</i>	Forest	Ellenberg et al. 1992
3	<i>Lathyrus pratensis</i>	Grassland	Ellenberg et al. 1992
3	<i>Melampyrum pratense</i>	Forest	Ellenberg et al. 1992
3	<i>Melilotus officinalis</i>	Unclassified	Ellenberg et al. 1992
3	<i>Mycelis muralis</i>	Forest	Ciocârlan 2009
3	<i>Plantago major</i>	Grassland	Ellenberg et al. 1992
3	<i>Polygonatum odoratum</i>	Forest	Ellenberg et al. 1992
3	<i>Potentilla cinerea</i>	Grassland	Ellenberg et al. 1992
3	<i>Pteridium aquilinum</i>	Edge	Ciocârlan 2009
3	<i>Ranunculus acer</i>	Grassland	Ellenberg et al. 1992
3	<i>Sanguisorba minor</i>	Grassland	Ellenberg et al. 1992
3	<i>Silene nutans</i> subsp. <i>dubia</i>	Grassland	Ciocârlan 2009
3	<i>Thesium linophyllum</i>	Grassland	Ellenberg et al. 1992
3	<i>Thymus comosus</i>	Grassland	Ciocârlan 2009
2	<i>Acinos arvensis</i>	Grassland	Ellenberg et al. 1992
2	<i>Ajuga genevensis</i>	Grassland	Ellenberg et al. 1992
2	<i>Antennaria dioica</i>	Grassland	Ellenberg et al. 1992
2	<i>Anthericum ramosum</i>	Edge	Ellenberg et al. 1992
2	<i>Campanula glomerata</i>	Grassland	Ellenberg et al. 1992

Constancy (%)	Species name	Habitat category	Source
2	<i>Campanula patula</i>	Grassland	Ellenberg et al. 1992
2	<i>Convolvulus arvensis</i>	Grassland	Ellenberg et al. 1992
2	<i>Daucus carota</i>	Grassland	Ellenberg et al. 1992
2	<i>Euphorbia angulata</i>	Edge	Ciocârlan 2009
2	<i>Festuca ovina</i>	Grassland	Ellenberg et al. 1992
2	<i>Galium aparine</i>	Edge	Ciocârlan 2009
2	<i>Jurinea mollis</i>	Grassland	Ciocârlan 2009
2	<i>Laserpitium latifolium</i>	Edge	Ellenberg et al. 1992
2	<i>Linum catharticum</i>	Grassland	Ellenberg et al. 1992
2	<i>Lysimachia nummularia</i>	Unclassified	Ellenberg et al. 1992
2	<i>Melittis melissophyllum</i>	Edge	Ellenberg et al. 1992
2	<i>Nepeta nuda</i> subsp. <i>nuda</i>	Edge	Ellenberg et al. 1992
2	<i>Ononis arvensis</i>	Grassland	Ellenberg et al. 1992
2	<i>Plantago media</i>	Grassland	Ellenberg et al. 1992
2	<i>Poa nemoralis</i>	Forest	Ellenberg et al. 1992
2	<i>Potentilla alba</i>	Edge	Ciocârlan 2009
2	<i>Prunella laciniata</i>	Grassland	Ellenberg et al. 1992
2	<i>Pyrus pyraister</i>	Forest	Ellenberg et al. 1992
2	<i>Senecio papposus</i>	Edge	Ciocârlan 2009
2	<i>Seseli annuum</i>	Grassland	Ellenberg et al. 1992
2	<i>Solidago virgaurea</i>	Unclassified	Ellenberg et al. 1992
2	<i>Symphytum tuberosum</i>	Forest	Ellenberg et al. 1992
2	<i>Trifolium alpestre</i>	Edge	Ellenberg et al. 1992
1	<i>Aegopodium podagraria</i>	Unclassified	Ellenberg et al. 1992
1	<i>Anemone nemorosa</i>	Forest	Ellenberg et al. 1992
1	<i>Anthyllis vulneraria</i>	Grassland	Ellenberg et al. 1992
1	<i>Astragalus glycyphylus</i>	Edge	Ellenberg et al. 1992
1	<i>Athyrium filix-femina</i>	Forest	Ciocârlan 2009
1	<i>Betula pendula</i>	Unclassified	Ellenberg et al. 1992
1	<i>Calamagrostis arundinacea</i>	Unclassified	Ellenberg et al. 1992
1	<i>Calamintha nepeta</i> subsp. <i>glandulosa</i>	Forest	Ellenberg et al. 1992
1	<i>Campanula sibirica</i>	Grassland	Ciocârlan 2009
1	<i>Campanula trachelium</i>	Forest	Ellenberg et al. 1992
1	<i>Cardamine bulbifera</i>	Forest	Ellenberg et al. 1992
1	<i>Cardaminopsis arenosa</i>	Unclassified	Ellenberg et al. 1992
1	<i>Carex digitata</i>	Forest	Ellenberg et al. 1992
1	<i>Carex michelii</i>	Edge	Ellenberg et al. 1992
1	<i>Carex pilosa</i>	Forest	Ellenberg et al. 1992
1	<i>Carex spicata</i>	Grassland	Ellenberg et al. 1992
1	<i>Carex sylvatica</i>	Forest	Ellenberg et al. 1992
1	<i>Carlina vulgaris</i>	Grassland	Ellenberg et al. 1992
1	<i>Carum carvi</i>	Grassland	Ellenberg et al. 1992
1	<i>Cephalanthera damasonium</i>	Forest	Ellenberg et al. 1992
1	<i>Cerastium sylvaticum</i>	Edge	Ciocârlan 2009
1	<i>Chaerophyllum aromaticum</i>	Grassland	Ellenberg et al. 1992
1	<i>Chaerophyllum aureum</i>	Grassland	Ellenberg et al. 1992
1	<i>Cirsium canum</i>	Grassland	Ellenberg et al. 1992
1	<i>Colchicum autumnale</i>	Grassland	Ellenberg et al. 1992
1	<i>Crepis biennis</i>	Grassland	Ellenberg et al. 1992
1	<i>Cynosurus cristatus</i>	Grassland	Ellenberg et al. 1992
1	<i>Dactylorhiza maculata</i>	Unclassified	Ellenberg et al. 1992
1	<i>Dianthus giganteus</i>	Grassland	Ciocârlan 2009
1	<i>Dryopteris filix-mas</i>	Forest	Ellenberg et al. 1992
1	<i>Eryngium campestre</i>	Grassland	Ellenberg et al. 1992
1	<i>Erysimum odoratum</i>	Grassland	Ellenberg et al. 1992
1	<i>Euphrasia rostkoviana</i>	Grassland	Ellenberg et al. 1992

Constancy (%)	Species name	Habitat category	Source
1	<i>Fallopia dumetorum</i>	Edge	Ciocârlan 2009
1	<i>Festuca valesiaca</i>	Grassland	Ciocârlan 2009
1	<i>Galium schultesii</i>	Forest	Ellenberg et al. 1992
1	<i>Gentiana cruciata</i>	Grassland	Ellenberg et al. 1992
1	<i>Hedera helix</i>	Forest	Ellenberg et al. 1992
1	<i>Holcus lanatus</i>	Grassland	Ellenberg et al. 1992
1	<i>Hypericum hirsutum</i>	Edge	Ellenberg et al. 1992
1	<i>Hypochoeris maculata</i>	Edge	Ciocârlan 2009
1	<i>Inula conyza</i>	Edge	Ellenberg et al. 1992
1	<i>Lamium galeobdolon</i>	Forest	Ellenberg et al. 1992
1	<i>Lilium martagon</i>	Forest	Ellenberg et al. 1992
1	<i>Listera ovata</i>	Forest	Ellenberg et al. 1992
1	<i>Lolium perenne</i>	Grassland	Ellenberg et al. 1992
1	<i>Luzula pilosa</i>	Unclassified	Ellenberg et al. 1992
1	<i>Mentha longifolia</i>	Grassland	Ellenberg et al. 1992
1	<i>Moehringia trinervia</i>	Forest	Ellenberg et al. 1992
1	<i>Myosotis sylvatica</i>	Edge	Ellenberg et al. 1992
1	<i>Orchis coriophora</i>	Grassland	Ellenberg et al. 1992
1	<i>Peucedanum austriacum</i>	Unclassified	Ciocârlan 2009
1	<i>Poa angustifolia</i>	Grassland	Ellenberg et al. 1992
1	<i>Poa pratensis</i>	Grassland	Ellenberg et al. 1992
1	<i>Populus tremula</i>	Unclassified	Ellenberg et al. 1992
1	<i>Ranunculus bulbosus</i>	Grassland	Ellenberg et al. 1992
1	<i>Rhamnus catharticus</i>	Forest	Ellenberg et al. 1992
1	<i>Rubus</i> sp.	Unclassified	-
1	<i>Rumex acetosella</i>	Unclassified	Ellenberg et al. 1992
1	<i>Salvia verticillata</i>	Edge	Ellenberg et al. 1992
1	<i>Sanicula europaea</i>	Forest	Ellenberg et al. 1992
1	<i>Scabiosa columbaria</i>	Grassland	Ellenberg et al. 1992
1	<i>Scrophularia nodosa</i>	Forest	Ellenberg et al. 1992
1	<i>Sedum annuum</i>	Grassland	Ellenberg et al. 1992
1	<i>Sedum hispanicum</i>	Grassland	Ciocârlan 2009
1	<i>Seseli pallasii</i>	Grassland	Ciocârlan 2009
1	<i>Sesleria heuflerana</i>	Edge	Ciocârlan 2009
1	<i>Silene bupleuroides</i>	Grassland	Ciocârlan 2009
1	<i>Silene latifolia</i> subsp. <i>alba</i>	Edge	Ellenberg et al. 1992
1	<i>Silene viridiflora</i>	Edge	Ciocârlan 2009
1	<i>Silene vulgaris</i>	Unclassified	Ellenberg et al. 1992
1	<i>Sorbus aucuparia</i>	Unclassified	Ellenberg et al. 1992
1	<i>Sorbus torminalis</i>	Forest	Ellenberg et al. 1992
1	<i>Stachys recta</i>	Grassland	Ellenberg et al. 1992
1	<i>Stellaria media</i>	Edge	Ellenberg et al. 1992
1	<i>Teucrium montanum</i>	Grassland	Ellenberg et al. 1992
1	<i>Thalictrum aquilegifolium</i>	Edge	Ellenberg et al. 1992
1	<i>Torilis japonica</i>	Forest	Ellenberg et al. 1992
1	<i>Trifolium arvense</i>	Grassland	Ellenberg et al. 1992
1	<i>Trifolium campestre</i>	Grassland	Ellenberg et al. 1992
1	<i>Urtica dioica</i>	Unclassified	Ellenberg et al. 1992
1	<i>Verbascum chaixii</i> subsp. <i>austriacum</i>	Grassland	Ciocârlan 2009
1	<i>Veronica opaca</i>	Grassland	Ellenberg et al. 1992
1	<i>Viburnum lantana</i>	Forest	Ellenberg et al. 1992
1	<i>Vicia cracca</i>	Edge	Ellenberg et al. 1992