

Patterns of vegetation diversity in deep river valleys of the Bohemian Massif

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Zelený D. & Chytrý M. (2007): Environmental control of the vegetation pattern in deep river valleys of the Bohemian Massif. – *Preslia* 79: 205-222.

Zelený D. & Chytrý M.: Pattern of species richness in the topographically complex landscape of deep river valleys in the Bohemian Massif – **manuscript**.

Zelený D., Li C.-F. & Chytrý M.: Pattern of plant species richness along the gradient of landscape topographical heterogeneity: result of spatial mass effect or environmental shift? – **submitted manuscript**.

Zelený D. (2008): Co-occurrence-based assessment of species habitat specialization is affected by the size of species pool: reply to Fridley *et al.* (2007). – **Journal of Ecology**, *in press*.

Zelený D. & Chytrý M. (2007):

Environmental control of the vegetation pattern in deep river valleys of the Bohemian Massif.

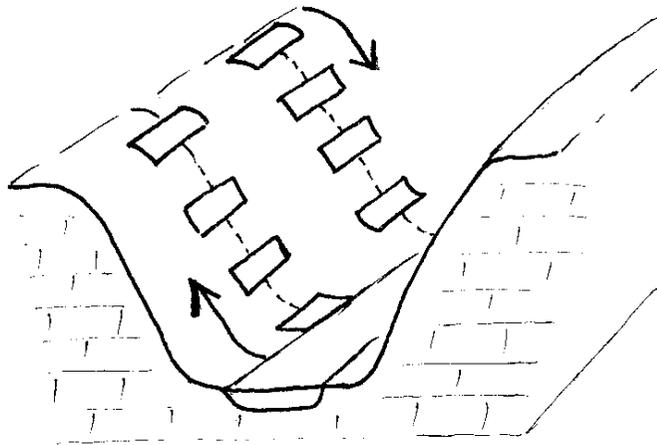
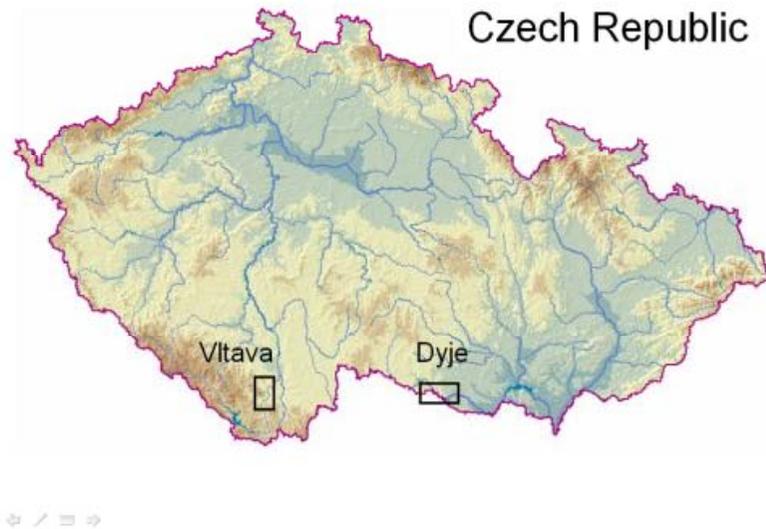
Preslia 79: 205-222

Question: What is the relationship between species composition of vegetation and the main ecological gradients in deep river valleys?

Study area: Vltava valley (DZ) and Dyje valley (MCh)

Data: vegetation plots sampled along transects down the slope of the valley

Analyses: NMDS, CCA, moving window CCA



Collecting field data:

where: steep valley slopes with natural and seminatural vegetation;

how: plots 10x15 m in even distances along the transect downslope;

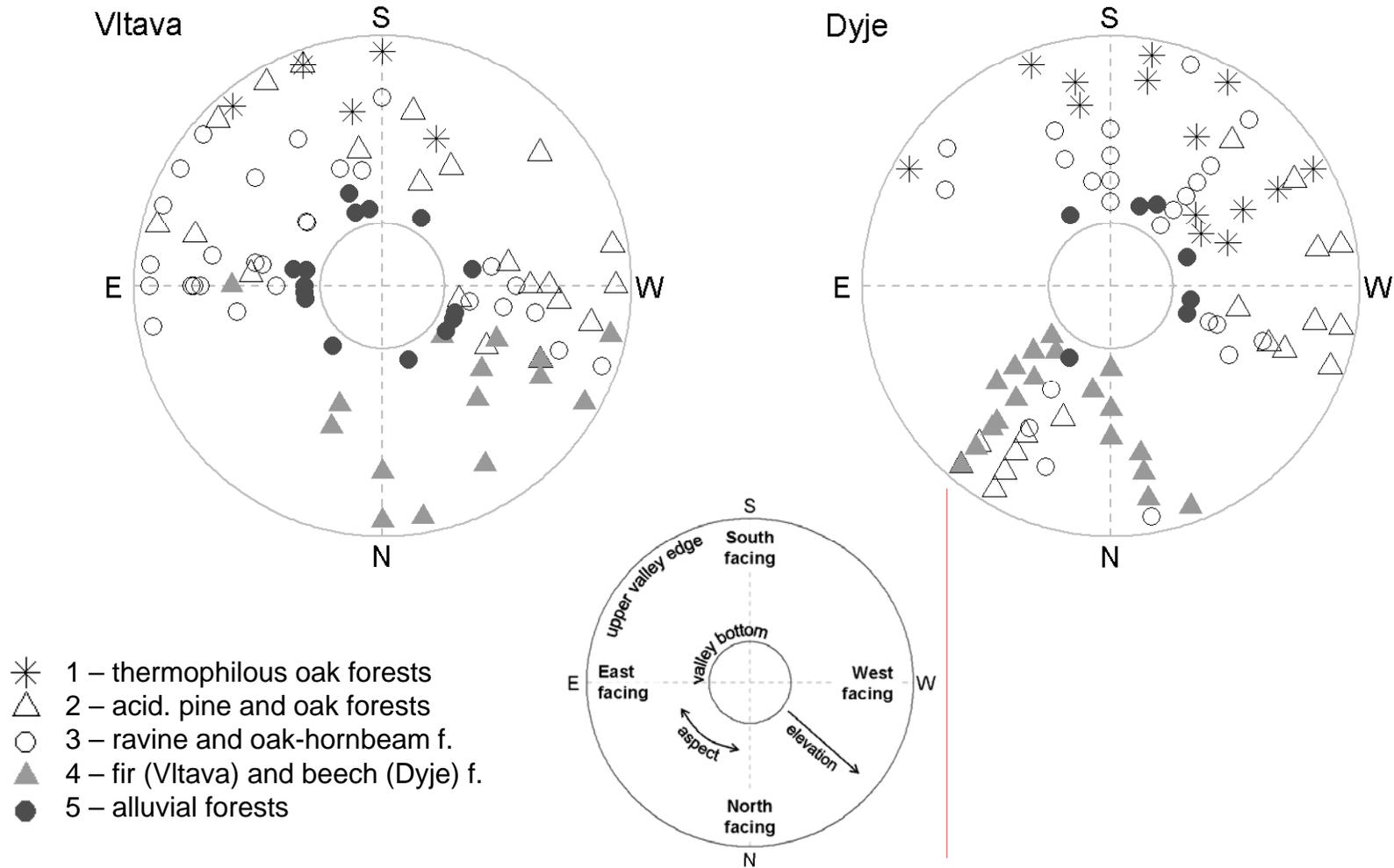
what was collected: data about vegetation (relevé) and environmental factors (topographical and soil);

how many: 94 plots (Vltava, collected by DZ) and 82 plots (Dyje, collected by MCh).



Vltava valley, close to Rohan, summer 2008 (photo by Ching Feng Li)

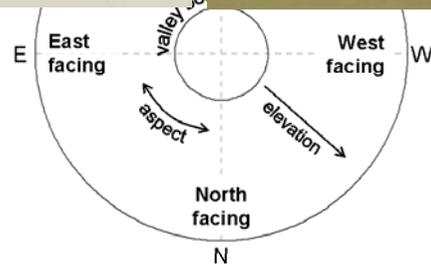
Distribution of vegetation types – iris diagrams



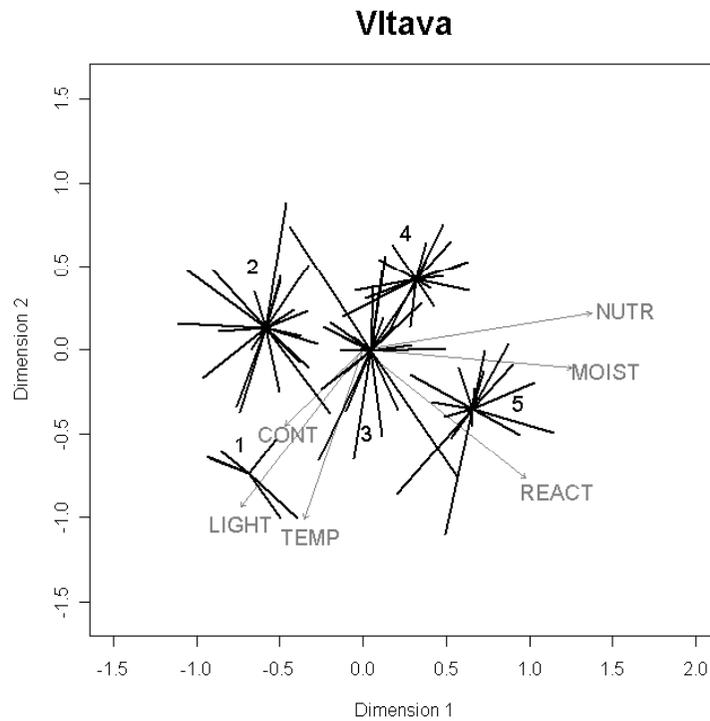
Distribution of vegetation types – iris diagrams



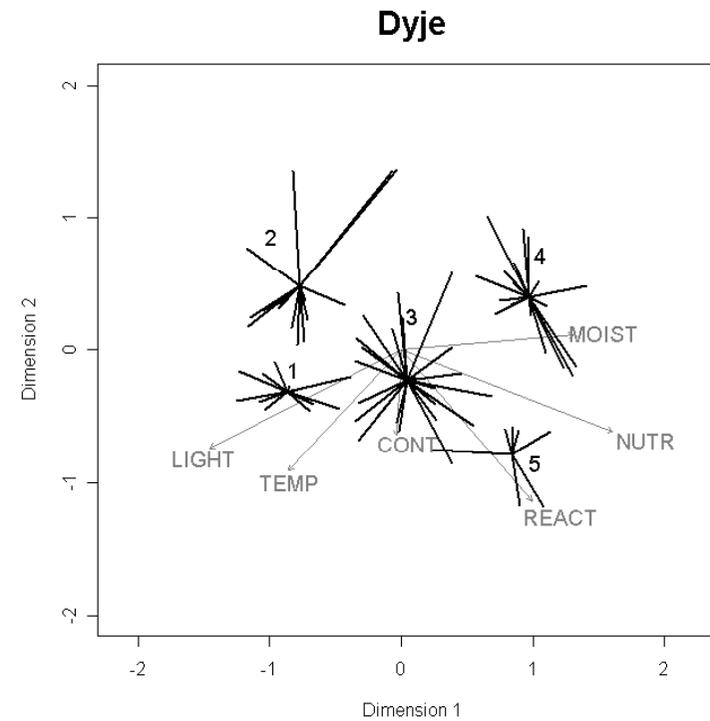
- * 1 – thermophilous oak forests
- △ 2 – acid. pine and oak forests
- 3 – ravine and oak-hornbeam f.
- ▲ 4 – fir (Vltava) and beech (Dyje) f.
- 5 – alluvial forests



NMDS ordination diagrams

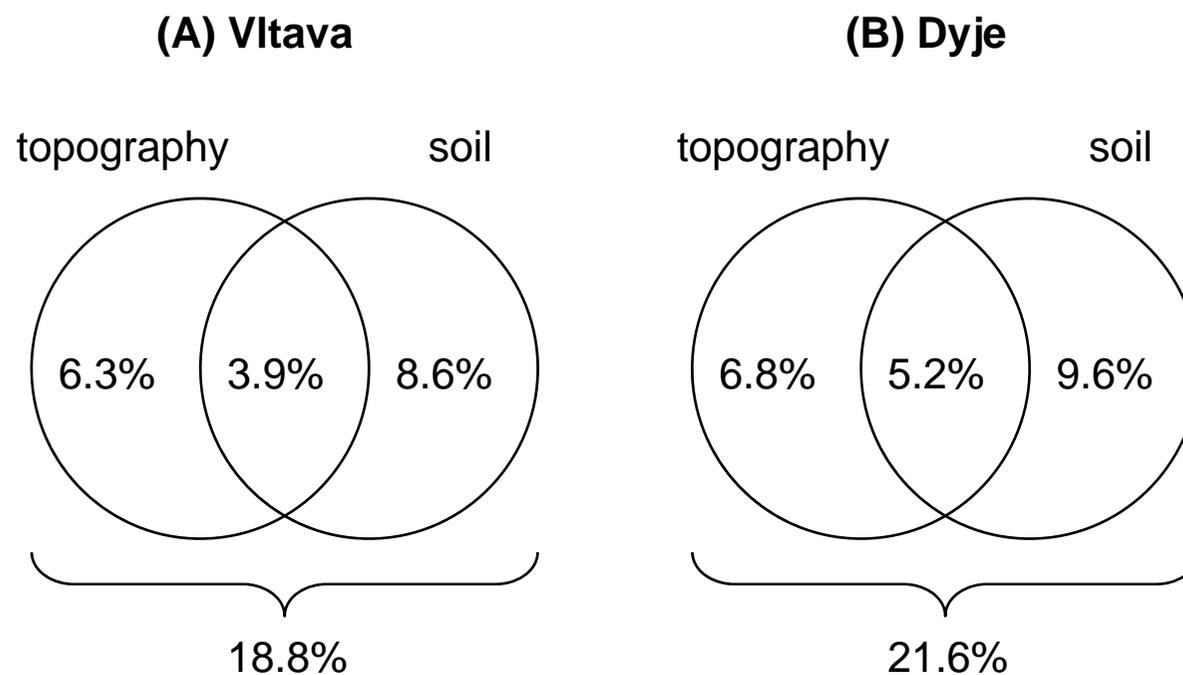


- 1 – thermophilous oak forests
- 2 – acidophilous oak and pine f.
- 3 – ravine and oak-hornbeam f.



- 4 – fir (Vltava) and beech (Dyje) f.
- 5 – alluvial forests

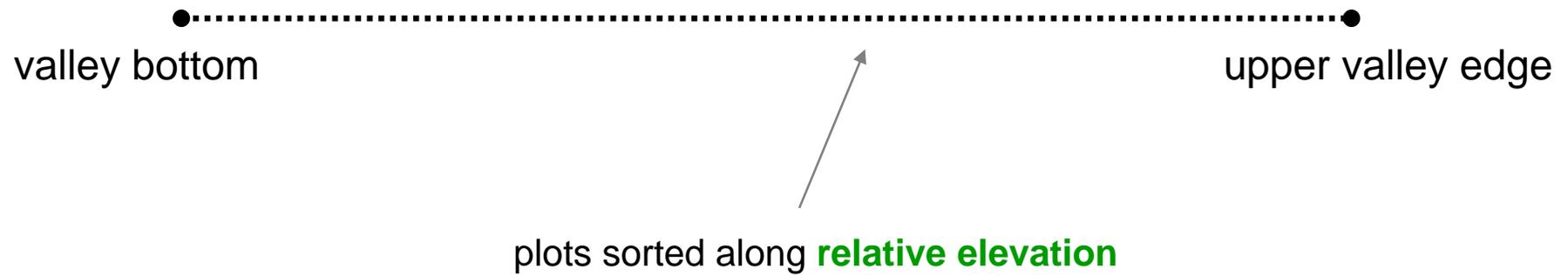
Variation in species composition explained by topographical and soil explanatory variables (CCA)



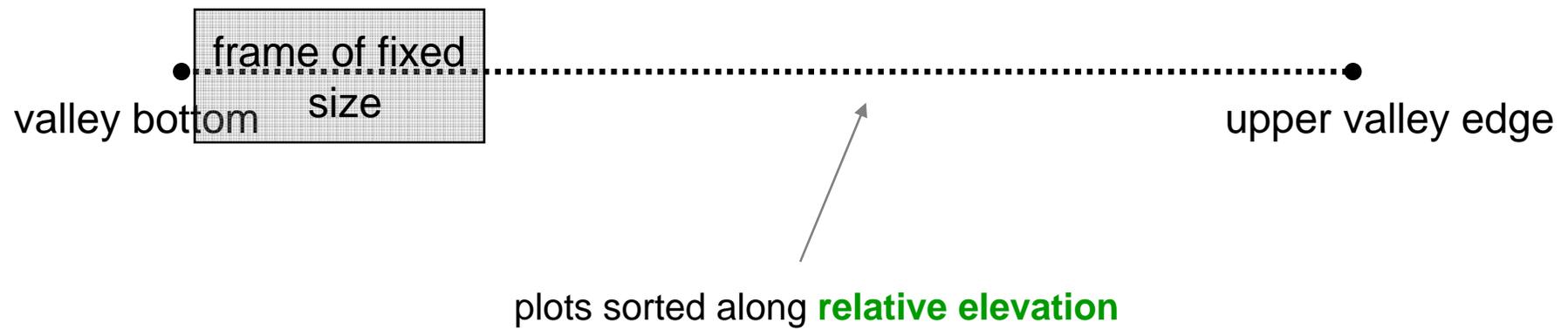
Moving window CCA

Is aspect as an environmental variable more important at the valley bottom, upper valley edge or in the middle?

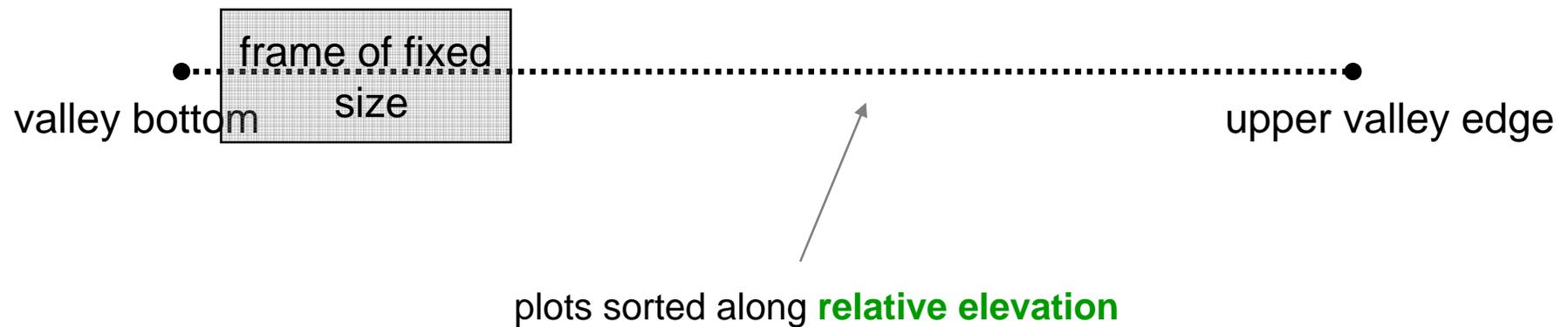
Moving window CCA



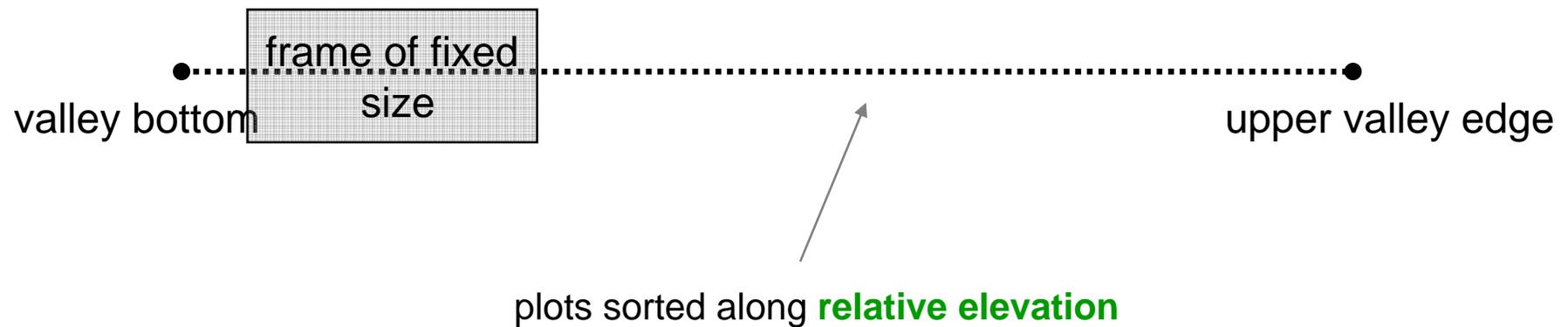
Moving window CCA



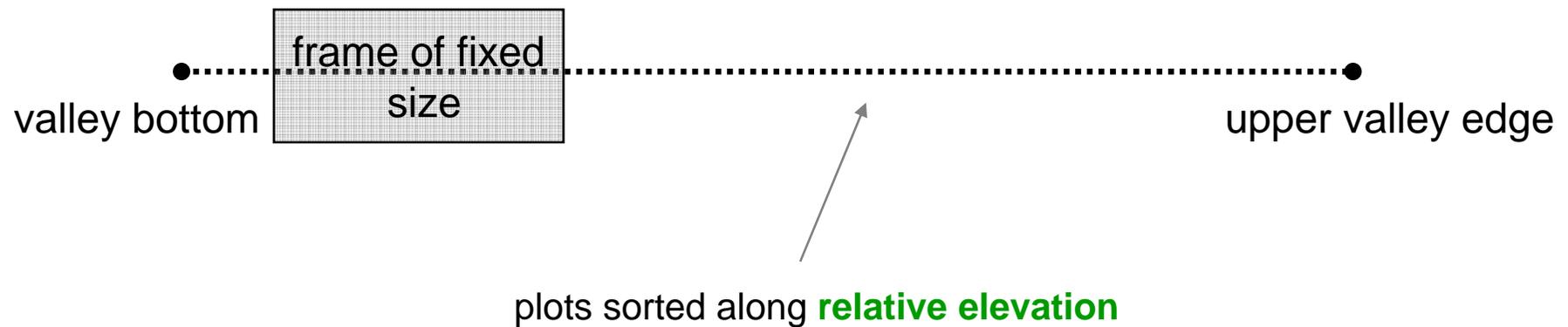
Moving window CCA



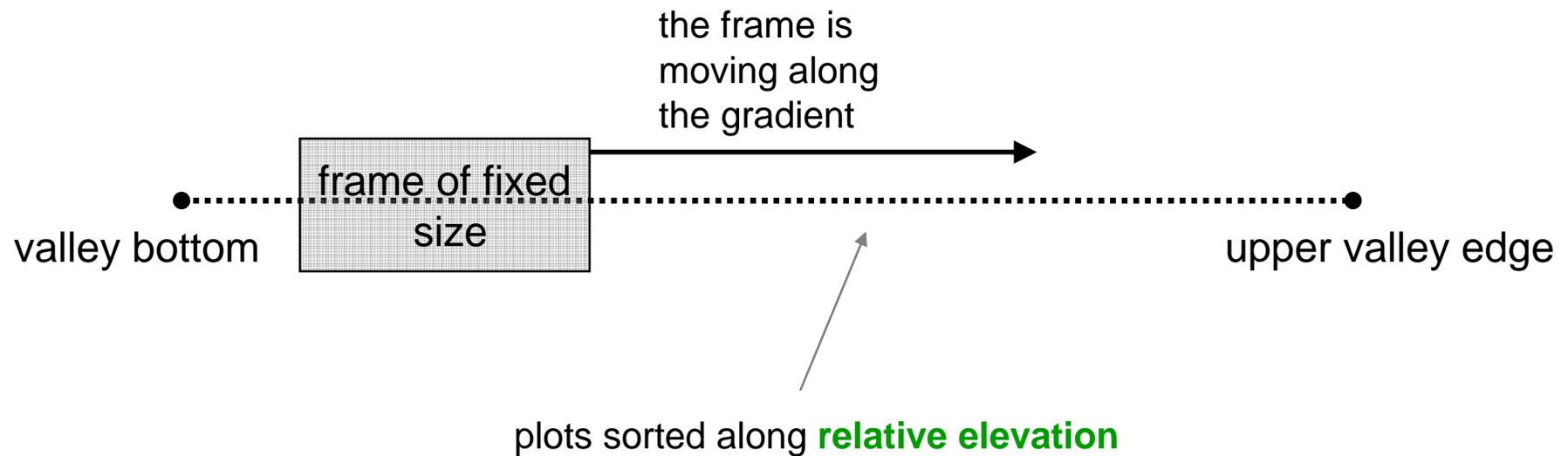
Moving window CCA



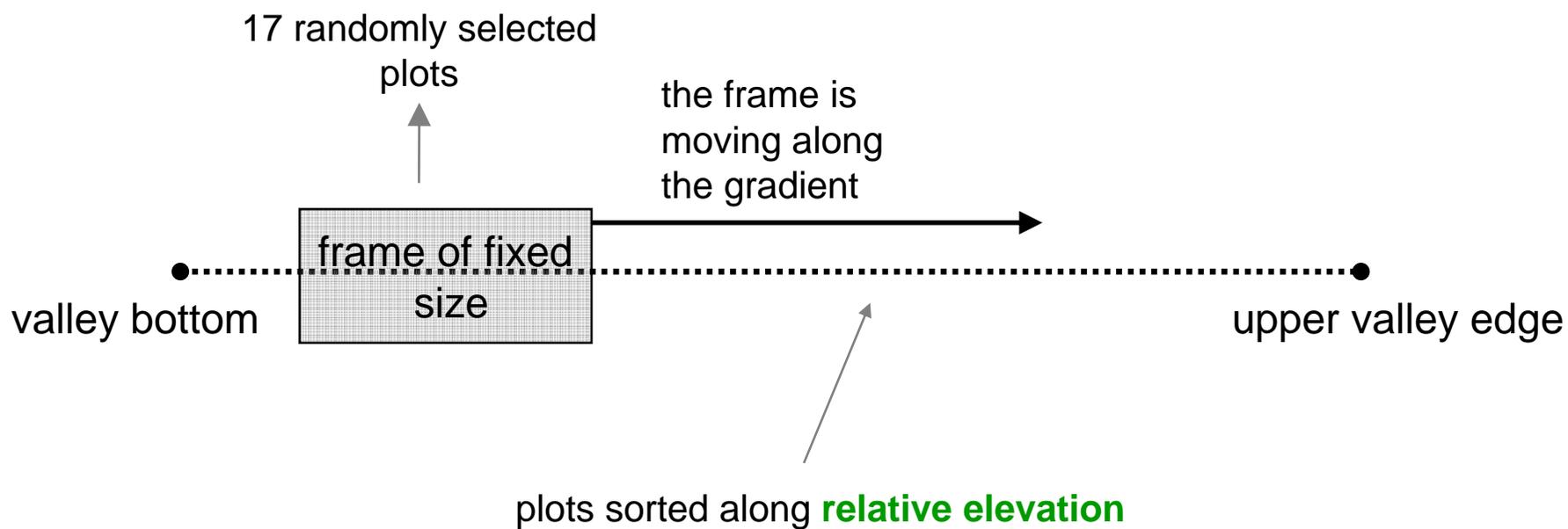
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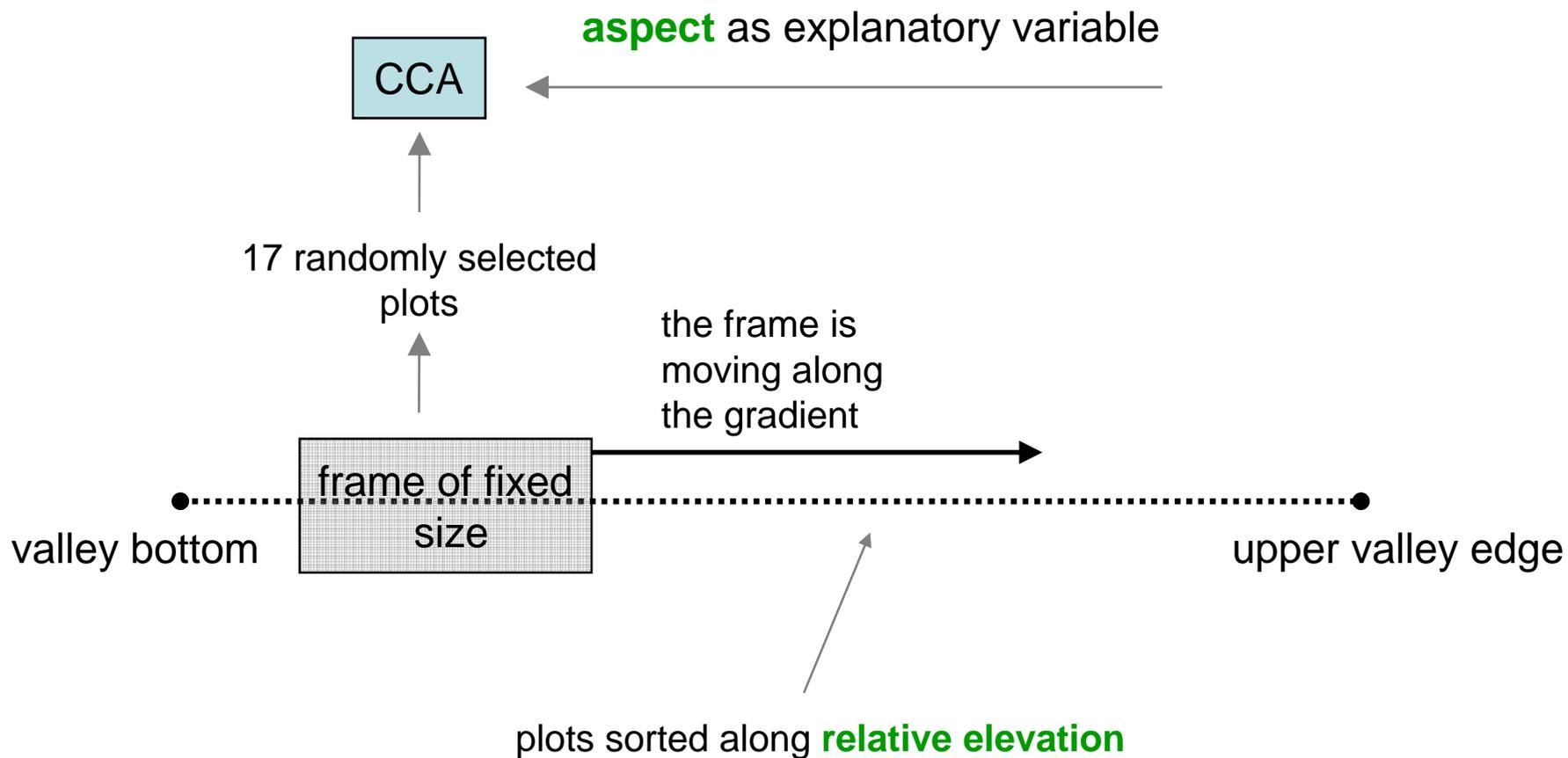
Moving window CCA



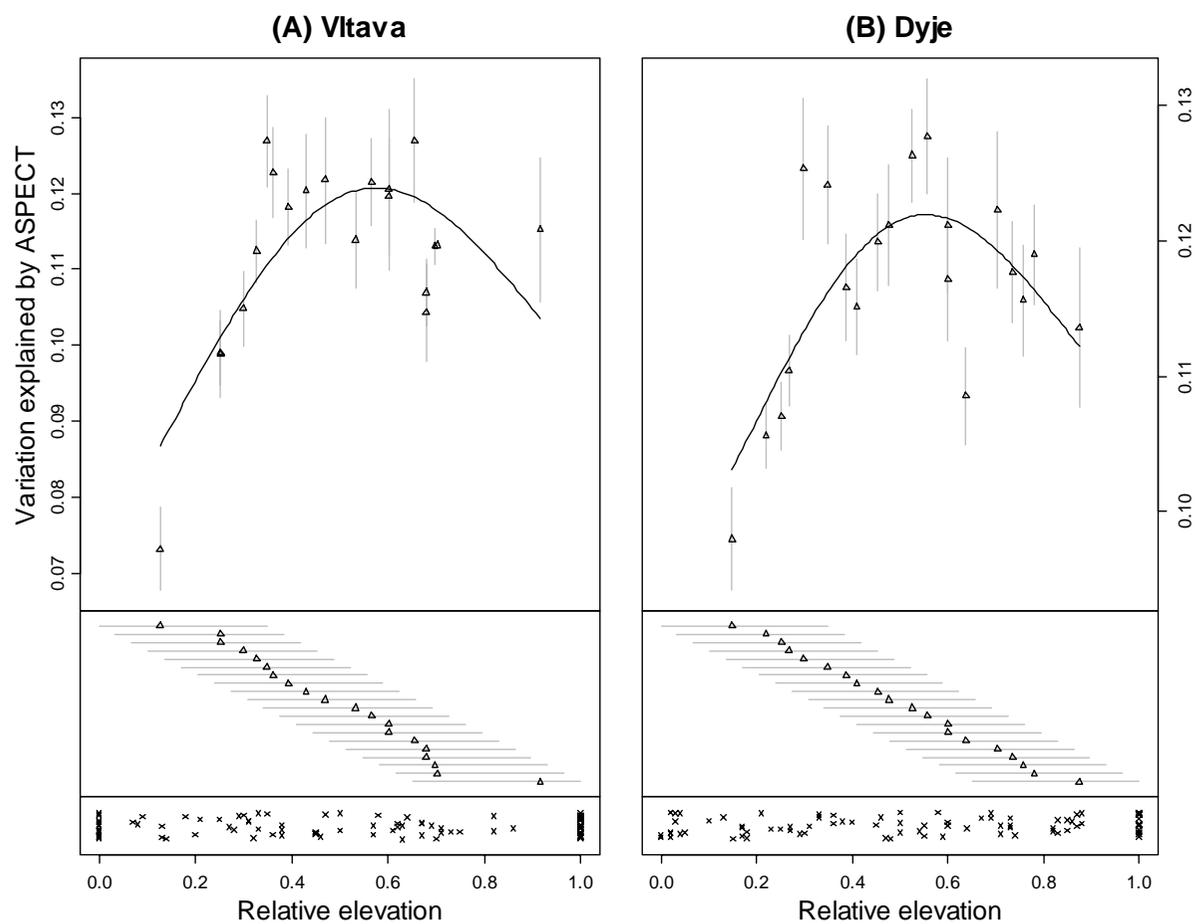
Moving window CCA



Moving window CCA



Moving window CCA



Paper 1: Conclusions

1. vegetation in deep river valleys is structured along two main complex ecological gradients: the moisture-nutrients-soil pH and the light-temperature-continentality gradient; the first one is related to the elevation above valley bottom, the second one to aspect;
2. the effect of aspect is mostly pronounced in the middle parts of the valley slopes, while being lowest at the shaded valley bottoms;
3. soil variables are slightly better predictors of vegetation composition than topographical variables;
4. the results of all analyses are similar in both valleys – and probably may be generalized also into other deep river valleys of mid-altitudes of the Bohemian Massif.

Zelený D. & Chytrý M.:

Pattern of species richness in the topographically complex landscape of deep river valleys in the Bohemian Massif

manuscript

Question: Which environmental factors are the best predictors of the local species richness in deep river valleys and how can be diversity-environment relationship influenced by differences in regional species pool?

Study area: Vltava valley (DZ) and Dyje valley (MCh).

Data: the same as in previous study.

Analyses: Generalized linear models

Poster presentation

16th Workshop of European Vegetation Survey

Rome, spring 2007



Pattern of α - and β -diversity of vegetation in deep river valleys of the Bohemian Massif

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Introduction

In the gently undulating landscape of the Bohemian Massif, which occupies a large part of the Czech Republic and adjacent areas of Germany and Austria, deep river valleys represent a distinct geomorphologic feature. Compared to other valley types, these are narrow, V-shaped valleys with steep slopes, large meanders, and a narrow, discontinuously developed floodplain. They are sharply incised into the flat or hilly landscapes, predominantly formed of acid bedrocks, especially granite and gneiss. Deep river valleys are considered to be "diversity hotspots" in landscape which is otherwise heavily affected by human activities. Fine scale spatial pattern and environmental control of plant diversity is the main aim of this study.

Main questions

What is the spatial pattern of α - and β -diversity of vegetation in deep river valleys and which environmental factors could be the best explanatory variables?



Fig. 1 - Location of study sites.

Table 1 - Explanatory variables used in the study

Topographic variables (quantitative and categorical data)	
ELEVATION	relative elevation above the valley bottom (β for the valley bottom, 1 for the upper edge)
SLOPE	slope inclination ($^\circ$; observed range: Vitava 0-80°, Dyje 5-77°)
SSW	aspect related to SSW; deviation of plot aspect from 22.5°; variable reaches the highest value for the supposedly warmest SSW aspect
SOUTH	aspect related to SOUTH; deviation of plot aspect from 0°
HEAT INDEX	heat index = $\cos(\text{aspect} - 202.5^\circ) \times \text{SLOPE}$
SURFACE SL	landform stage in the downslope direction (1 concave, 0 flat, 1 convex)
SURFACE ISO	landform stage along an isohyase (1 concave, 0 flat, 1 convex)
Soil variables and soil types (quantitative and presence-absence data)	
pH	active soil pH measured in water solution
SOIL DEPTH	soil depth, expressed as log [soil depth (cm)]
FLUVISOL	Fluvisols (water-influenced soils in floodplains)
SKELETIC	skeletal and hypogleptic Leptosols (soils on scree accumulations)
CAMBISOL	Cambisols (well-developed zonal soils)
LITHIC	lithic Leptosols (shallow soils near rock outcrops)

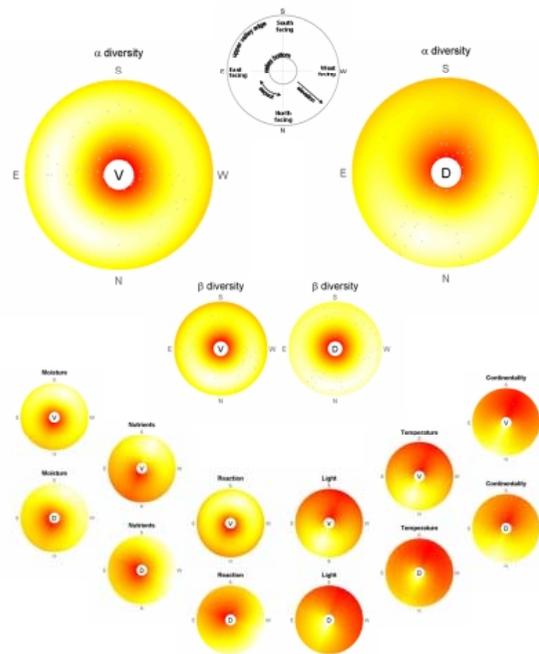


Fig. 2 - Set of 'donut plots' showing spatial distribution of α - and β -diversity and Ellenberg indicator values in an idealized model of deep river valley. Surface is modeled using GLM and drawn in reversed heat colors (red = high values, white = low values). V = Vitava valley, D = Dyje valley.

Results

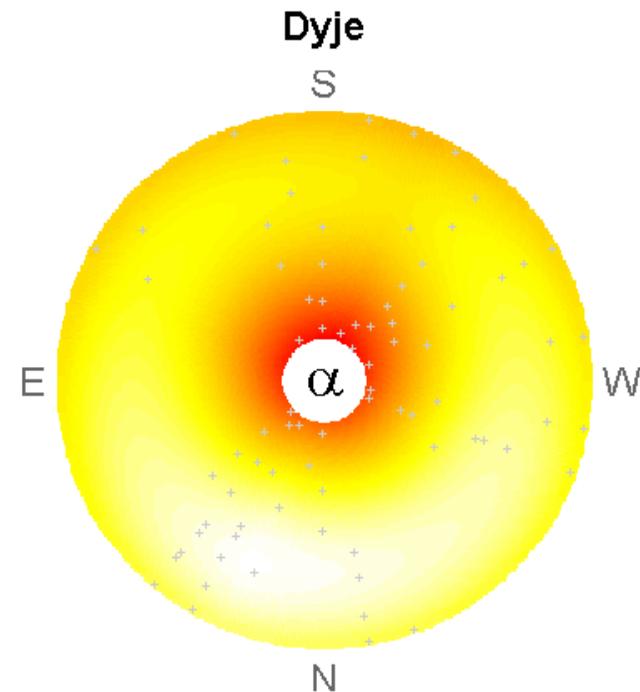
- Both valleys share similar spatial pattern of α - and β -diversity:
 - α -diversity (Fig. 2, eyes) is concentrated at the valley bottom and decreases in upslope direction. It is higher on south-facing slopes than on north-facing slopes. Additionally to this, in the Dyje valley the upper edges of south-facing slopes are richer in species.
 - β -diversity (Fig. 2, nose) is highest on the valley bottom and decreases upslope; lowest β -diversity is in the middle of the north-facing slopes.
- Generalized linear models (Table 2) revealed that:
 - in both valleys, α -diversity has a quadratic relationship with elevation above the valley bottom (peaking on the valley bottom and upper slopes) and is positively correlated with the presence of Cambisol and Fluvisol. Furthermore, in the Vitava valley α -diversity is positively correlated with pH, while in the Dyje valley it has quadratic response to heat index and positive linear response to landform shape in downslope direction.
 - β -diversity is best explained by elevation (quadratic response in the Vitava valley and linear response in the Dyje valley), and by measure of southernness (Vitava) or heat index (Dyje).
- Spatial patterns of ecological characteristics expressed through Ellenberg indicator values are presented in Fig. 2 (mouth).

Conclusions

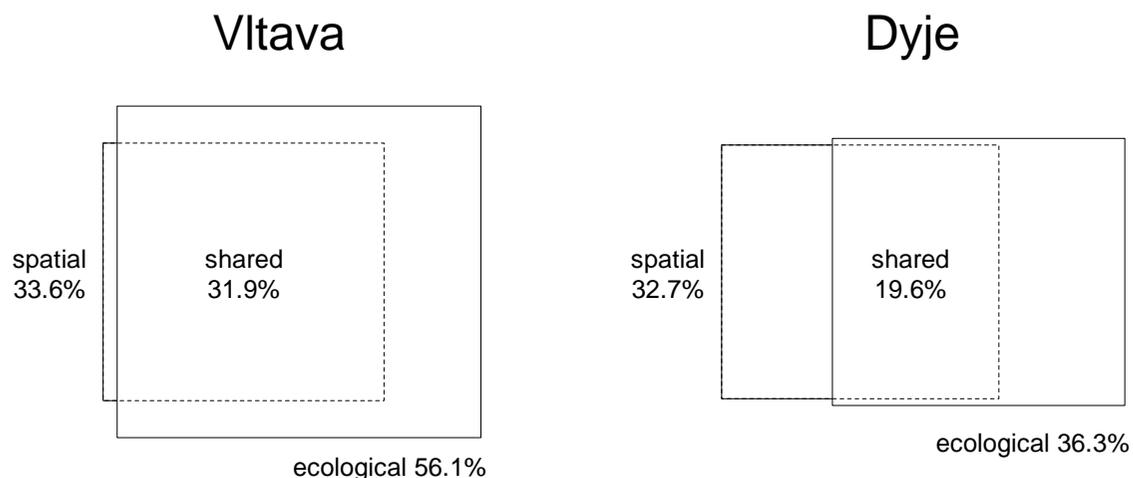
Two local hotspots of vegetation diversity can be recognized, one at the valley bottom (alluvial forest) and the other on the south-facing upper edges of the valley slopes (thermophilous oak forest). South-facing slopes are generally more species-rich than the north-facing slopes, however, quadratic relationship between species richness and heat index indicates unimodal response with low richness in extremely dry and warm habitats.

Spatial pattern of β -diversity shows interesting similarities to spatial pattern of α -diversity. β -diversity is concentrated in areas of high habitat heterogeneity, i.e. the valley bottom and the upper edges of (south-facing) slopes. These are also habitats supporting higher alpha diversity. The question is whether these similarities are only a result of co-occurrence or of more general processes of interaction between α - and β -diversity.

Spatial distribution of alpha diversity (herb layer species only) in deep river valley – donut plot



Variance in species richness explained by spatial and ecological variables



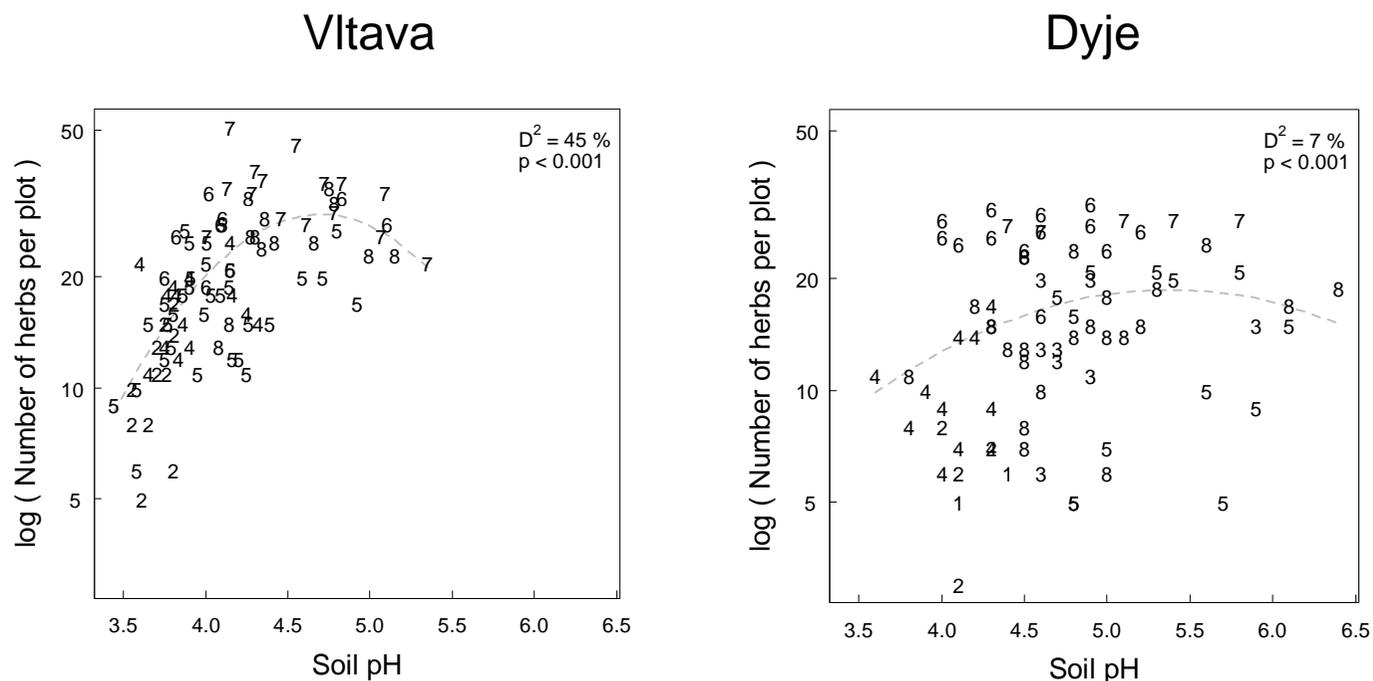
spatial: elevation (²) + aspect

ecological: pH (²) + Fluvisol + Heat load

spatial: elevation (²) + aspect

ecological: pH (²) + Fluvisol + Heat load + Cambisol + Lithic

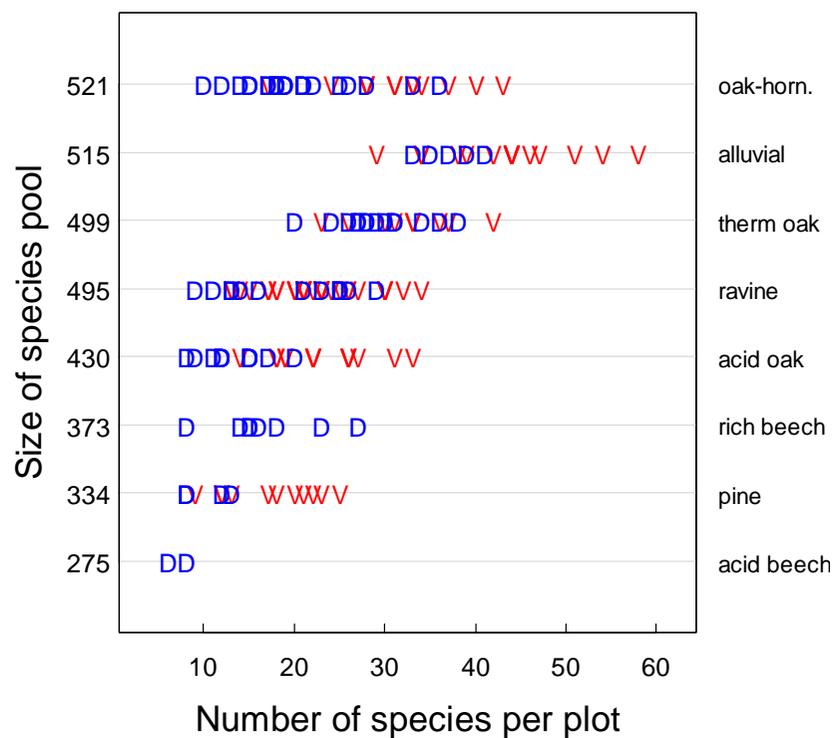
Relationship between species richness (herb layer species) and measured soil pH



Numbers refer to classification of plots into habitat types, following Sádlo et al. (2007):

1 – acidophilous beech forests, 2 – boreo-continental pine forests, 3 – herb-rich beech forests, 4 – acidophilous oak forests, 5 – ravine forests, 6 – thermophilous oak forests, 7 – alluvial forests and 8 – oak-hornbeam forests.

Relationship between species richness (herb layer species) and estimated habitat species pools (Sádlo et al. 2008)



Paper 2: Conclusions

1. the highest local species richness within the valley is located at the valley bottom and at the south and west facing upper edges of the valley slopes;
2. soil pH is a strong predictor of species richness, but only in case of Vltava river valley with predominating acid soils with values of pH < 4.5;
3. in case of Dyje valley, important factor related to high local species richness is continentality, resulting probably from the higher proportion of continental species in regional species pool of Dyje valley;
4. local species richness is positively correlated with the size of regional species pool estimated for particular habitat types; this indicates that estimates of species pool size itself may be a good predictor of real local species richness.

David Zelený, Ching-Feng Li & Milan Chytrý

Pattern of plant species richness along the gradient of
landscape topographic heterogeneity:
result of spatial mass effect or
environmental shift?

submitted manuscript

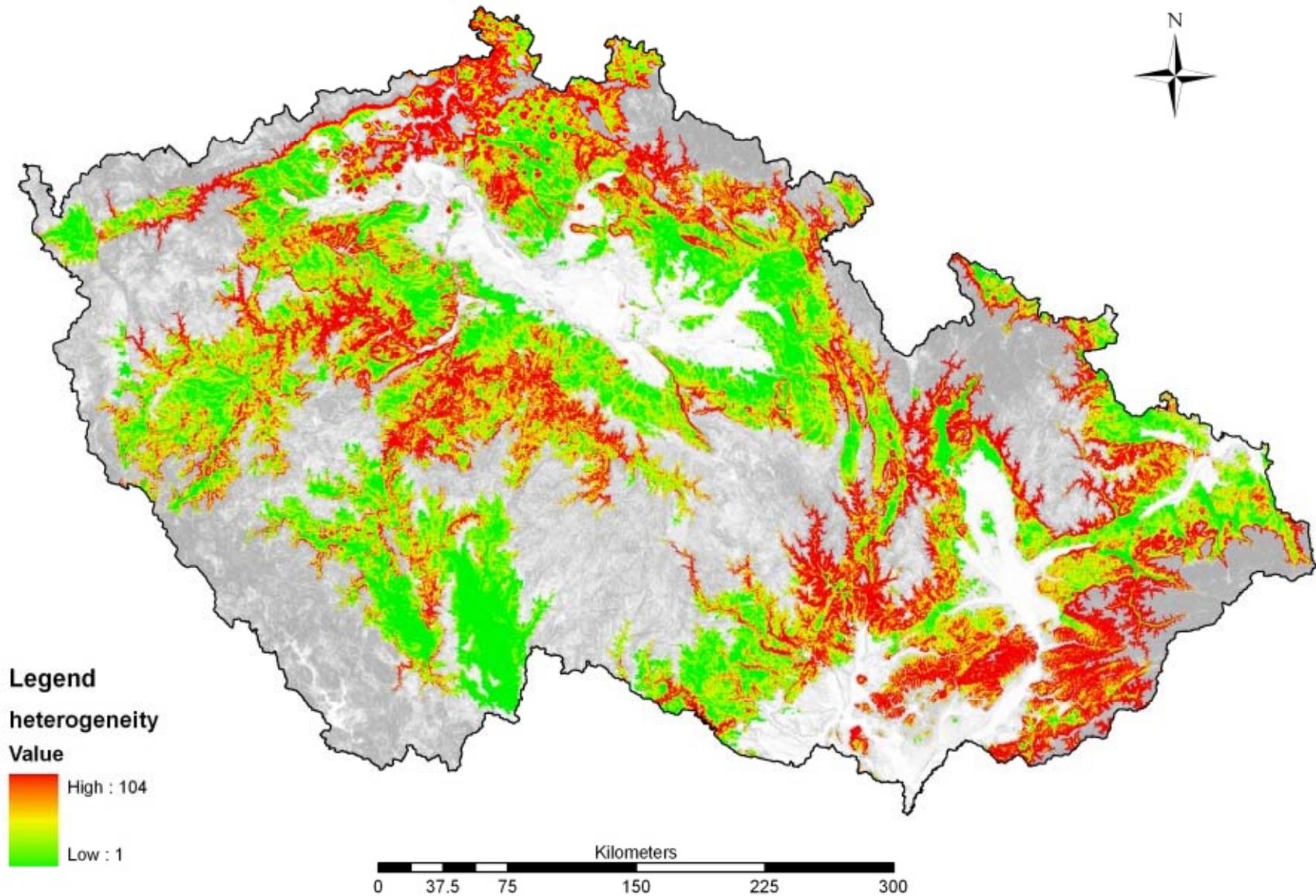
Main question: How is the species richness of microsite correlated with the heterogeneity of surrounding landscape?

Study area: Czech Republic, 250-480 m a.s.l.

Data: Forest vegetation, phytosociological relevés from the Czech National Vegetation Database, 250-480 m a.s.l.

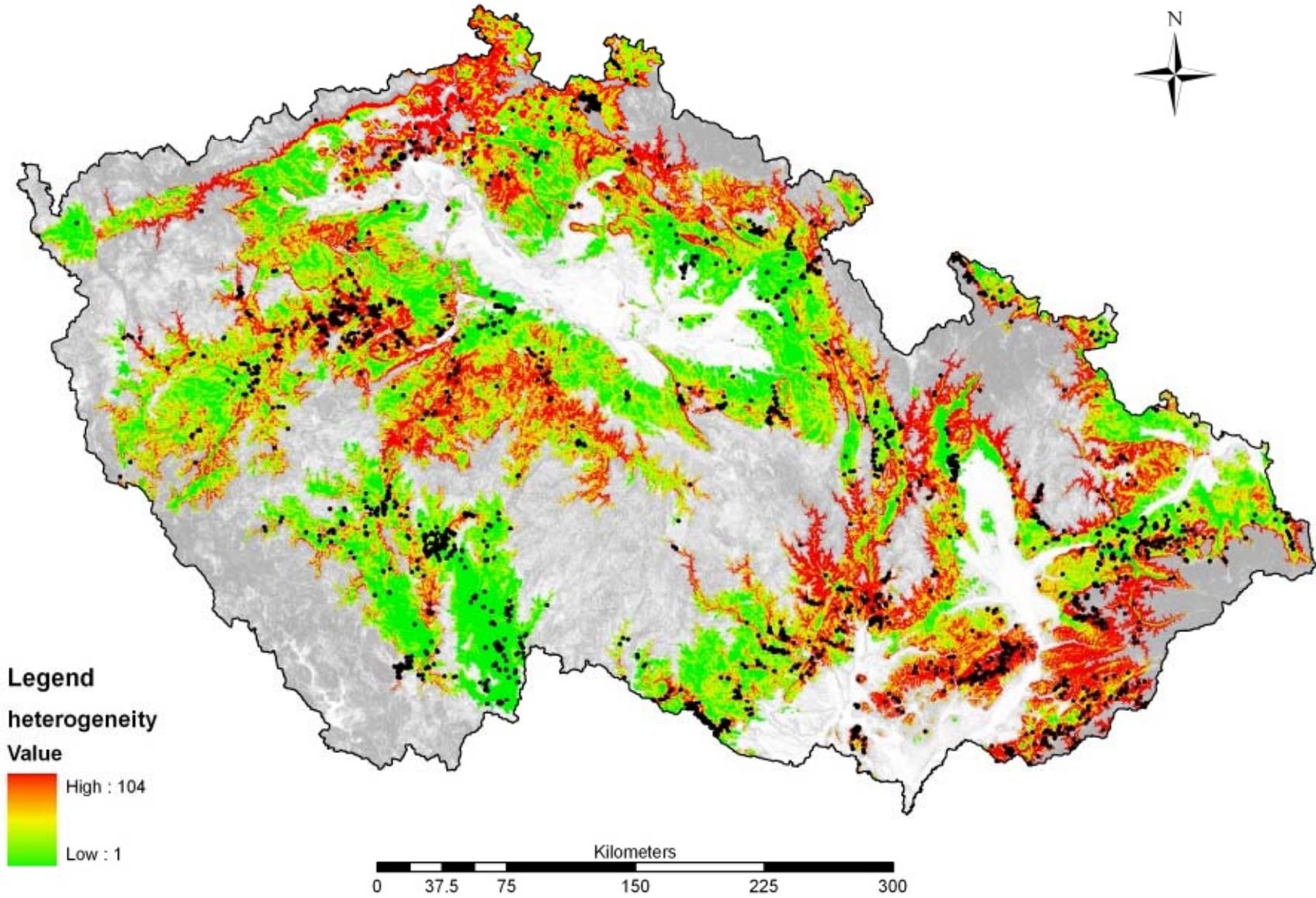
Analyses: 'repeated-correlation analysis', NMDS, GIS

Topographic heterogeneity within the Czech Republic (250-480 m a.s.l.)



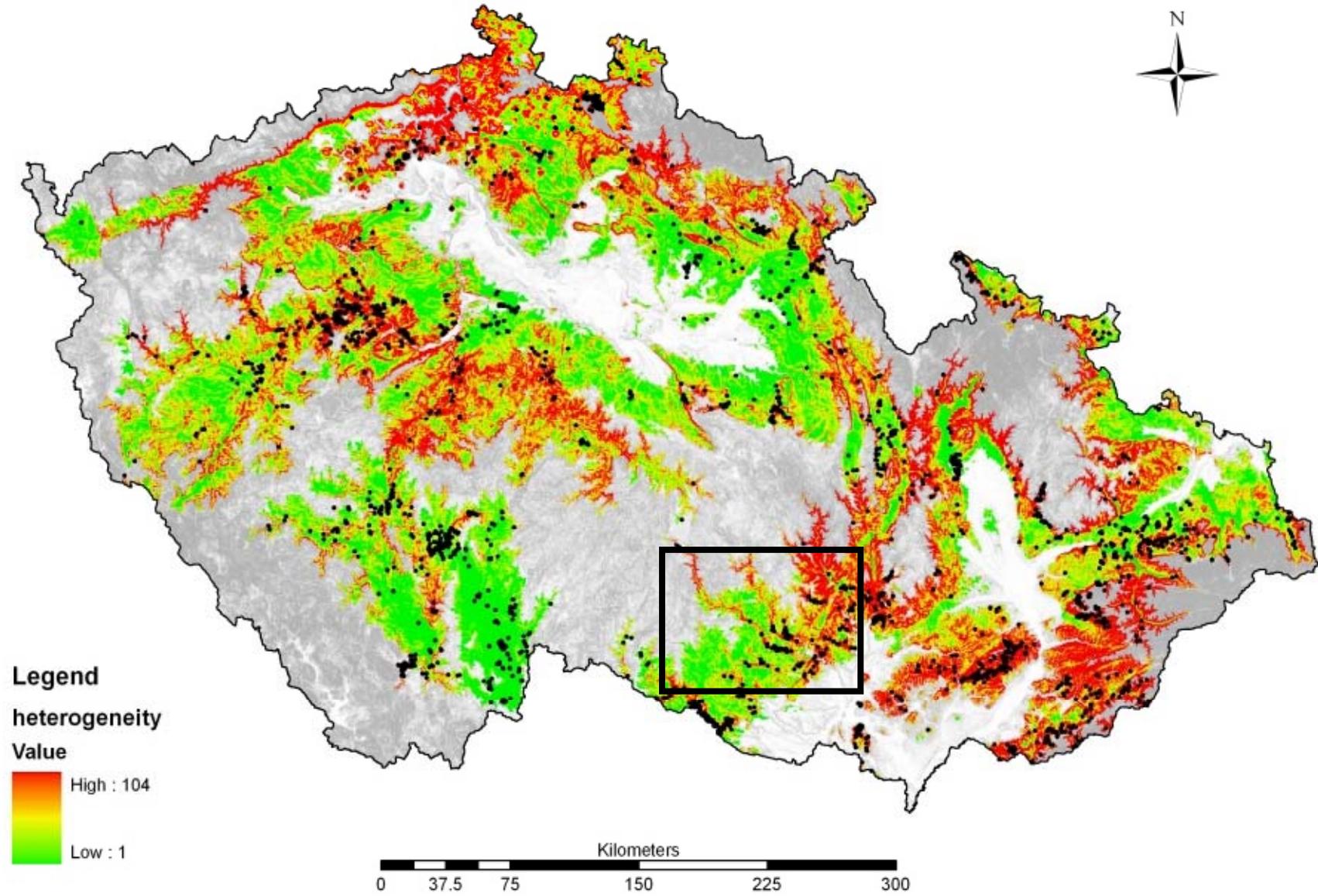
Zelený D. , Li Ch.-F. & Chytrý M. (submitted): Pattern of plant species richness along the gradient of landscape topographic heterogeneity: result of spatial mass effect or environmental shift?

2551 forest vegetation relevés from Czech National Vegetation Database

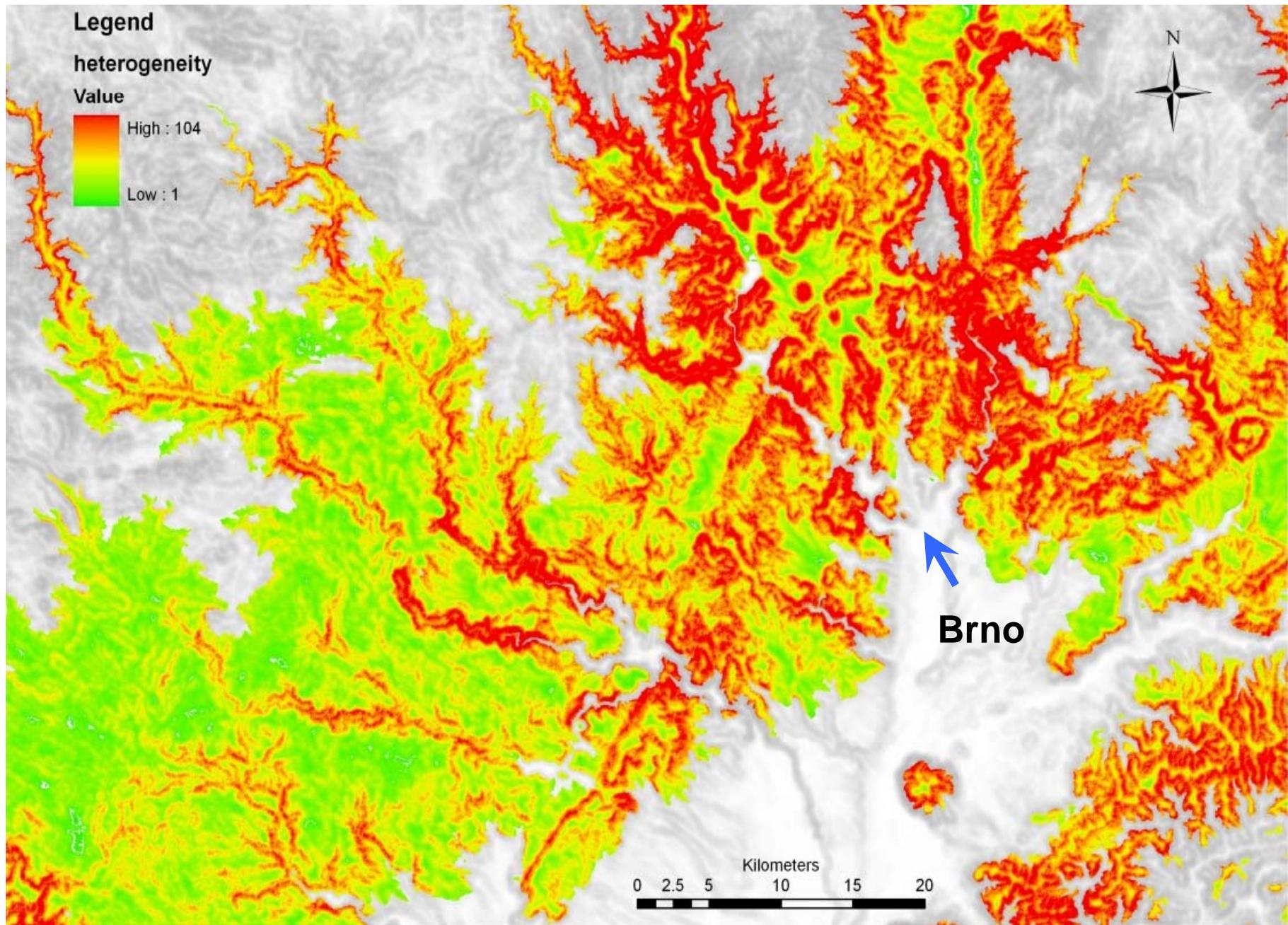


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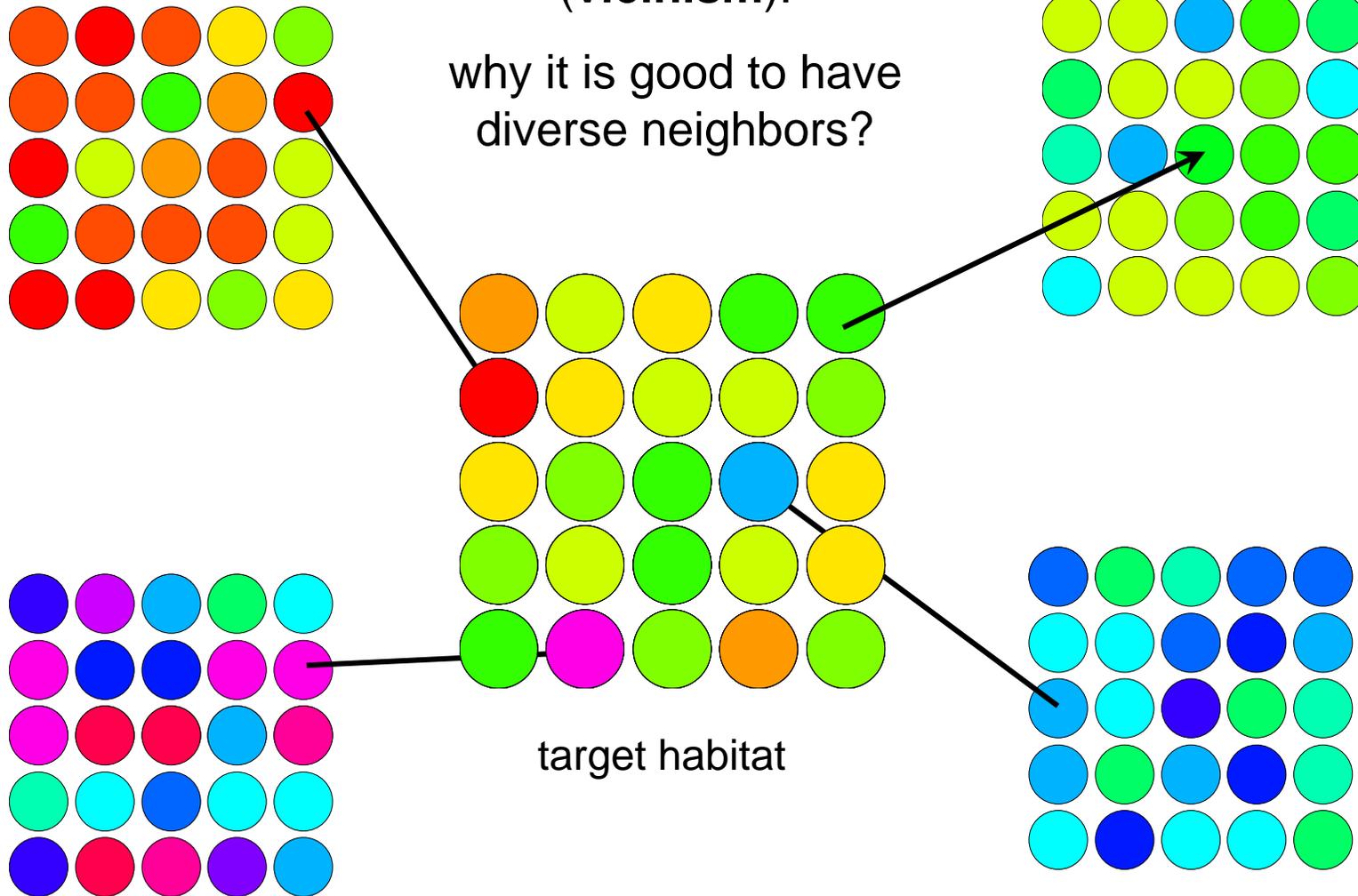


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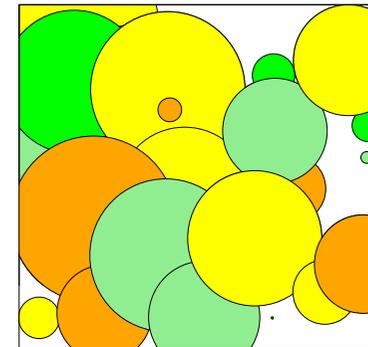
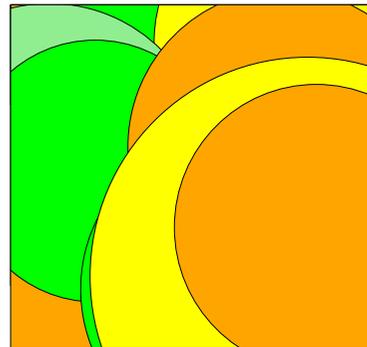
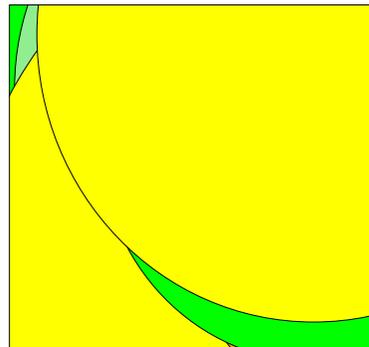
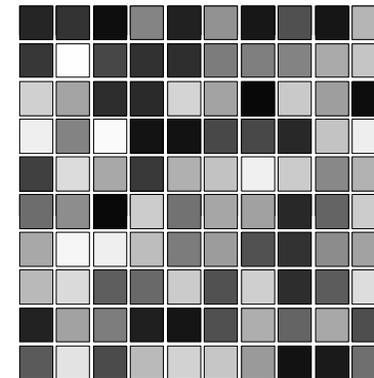
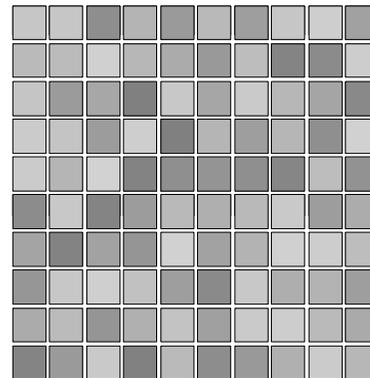
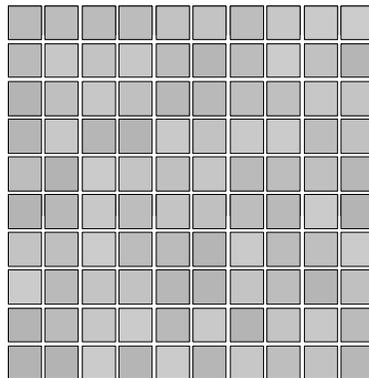


Spatial mass effect (vicinism):

why it is good to have
diverse neighbors?



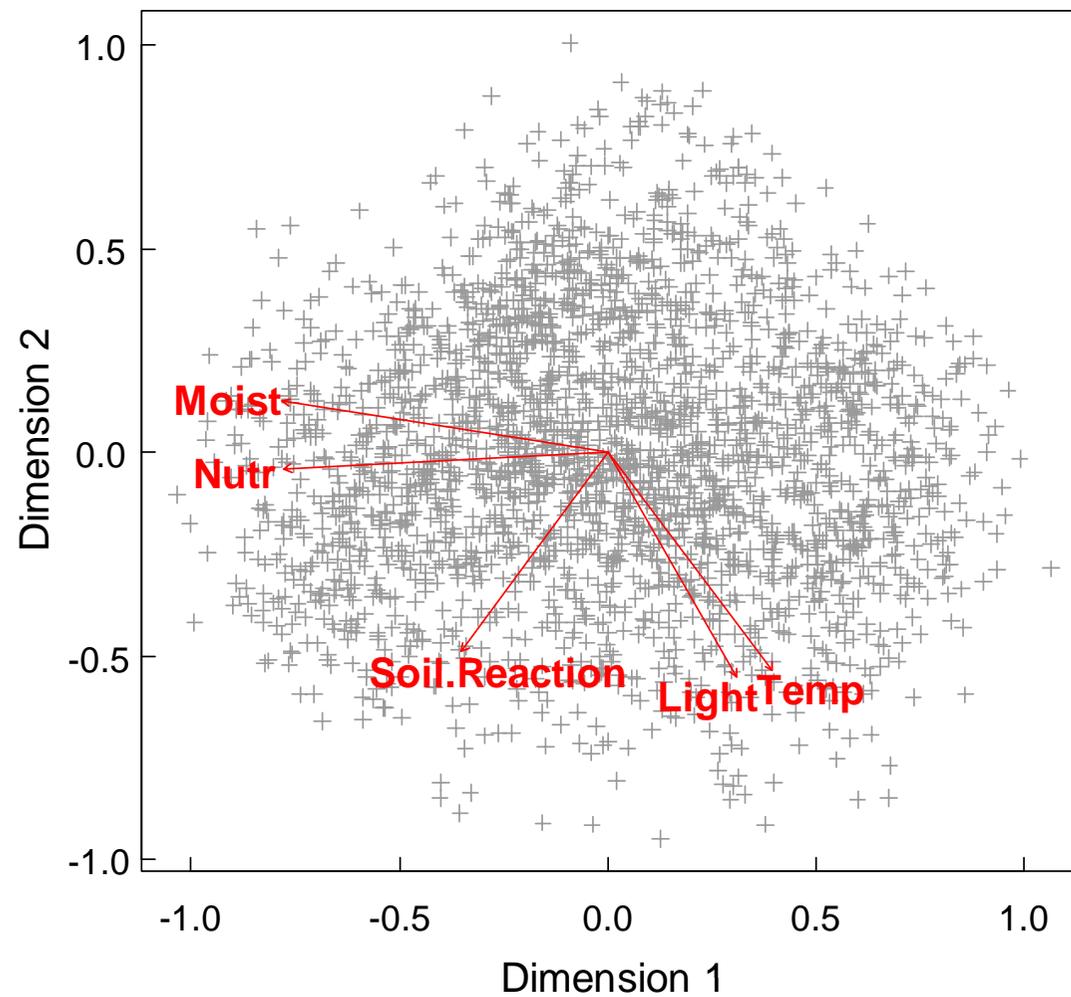
increasing topographic heterogeneity of landscape



increasing habitat diversity and increasing fragmentation

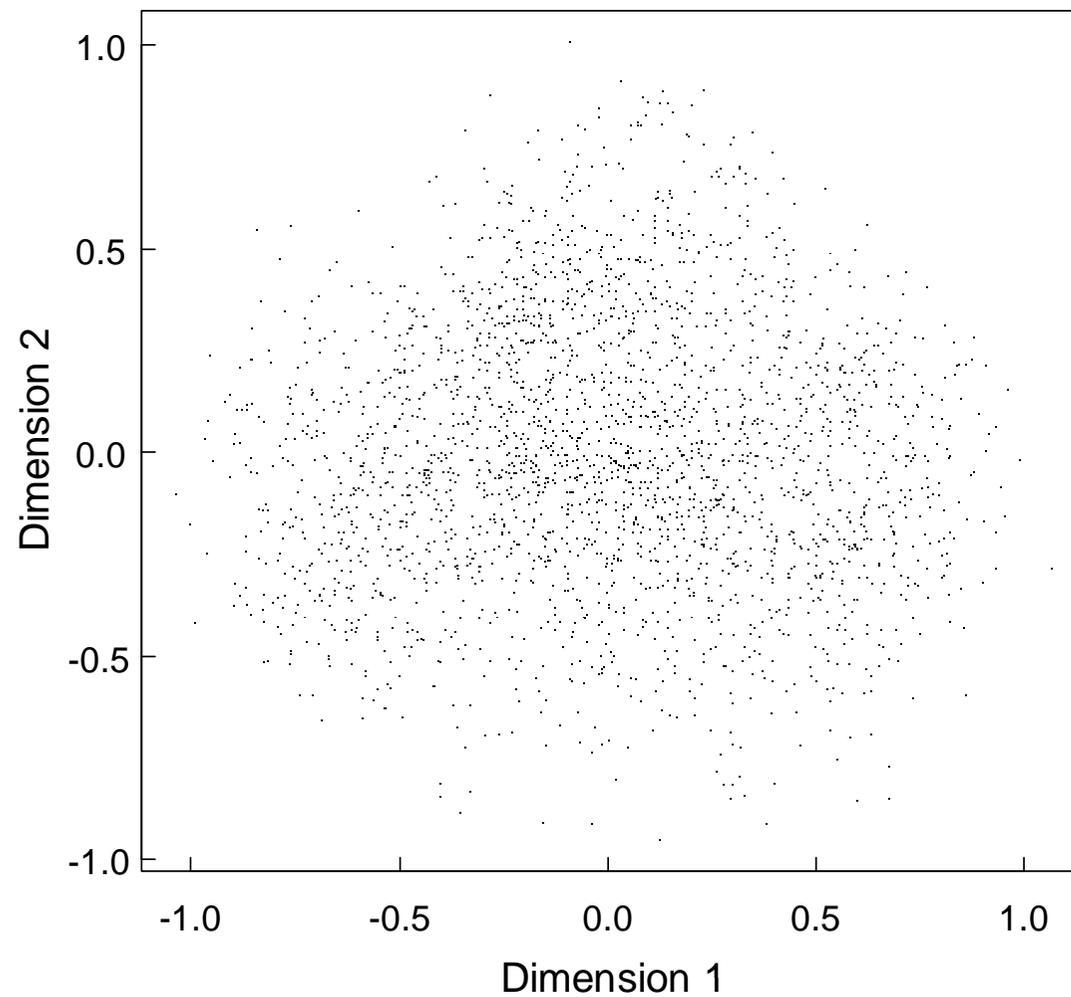
Zelený D. , Li Ch.-F. & Chytrý M. (submitted): Pattern of plant species richness along the gradient of landscape topographic heterogeneity: result of spatial mass effect or environmental shift?

NMDS of 2551 forest relevés



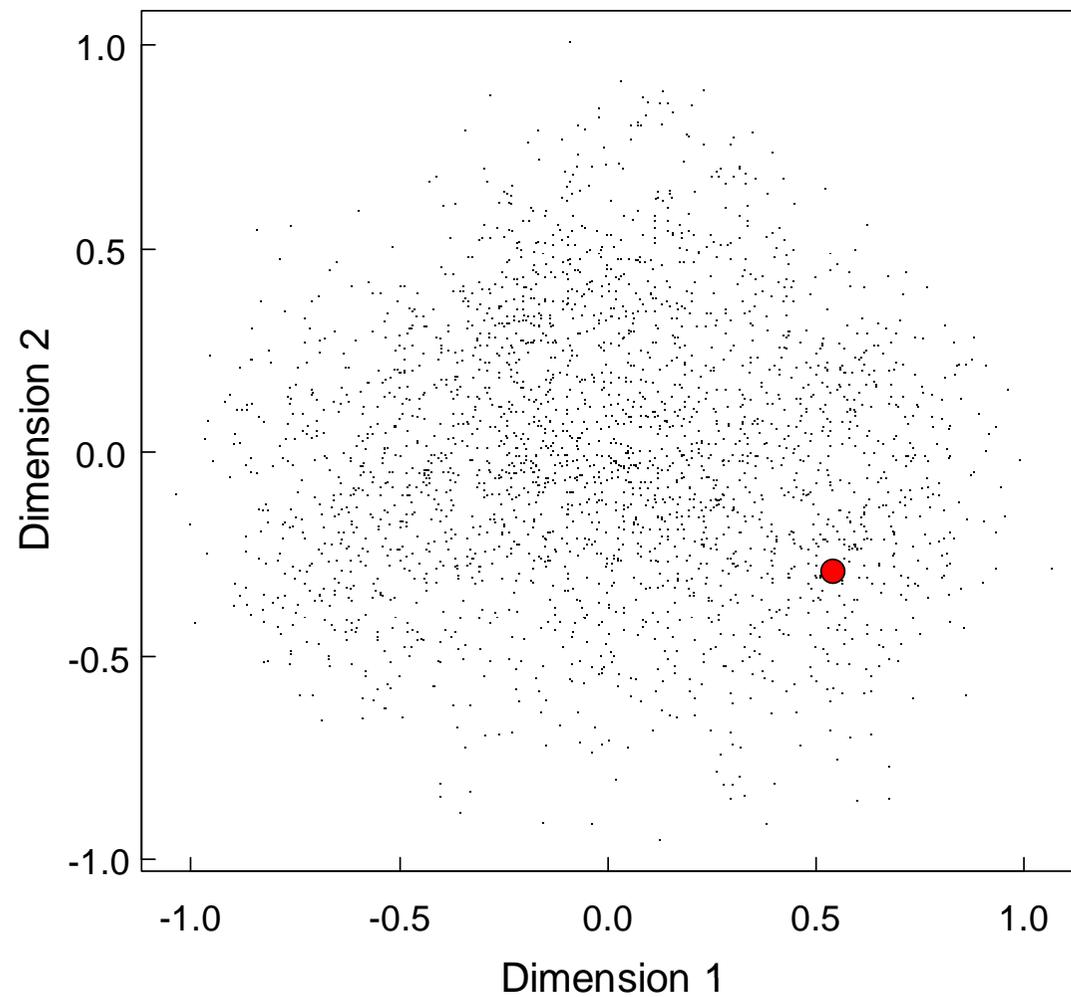
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Species richness vs. heterogeneity



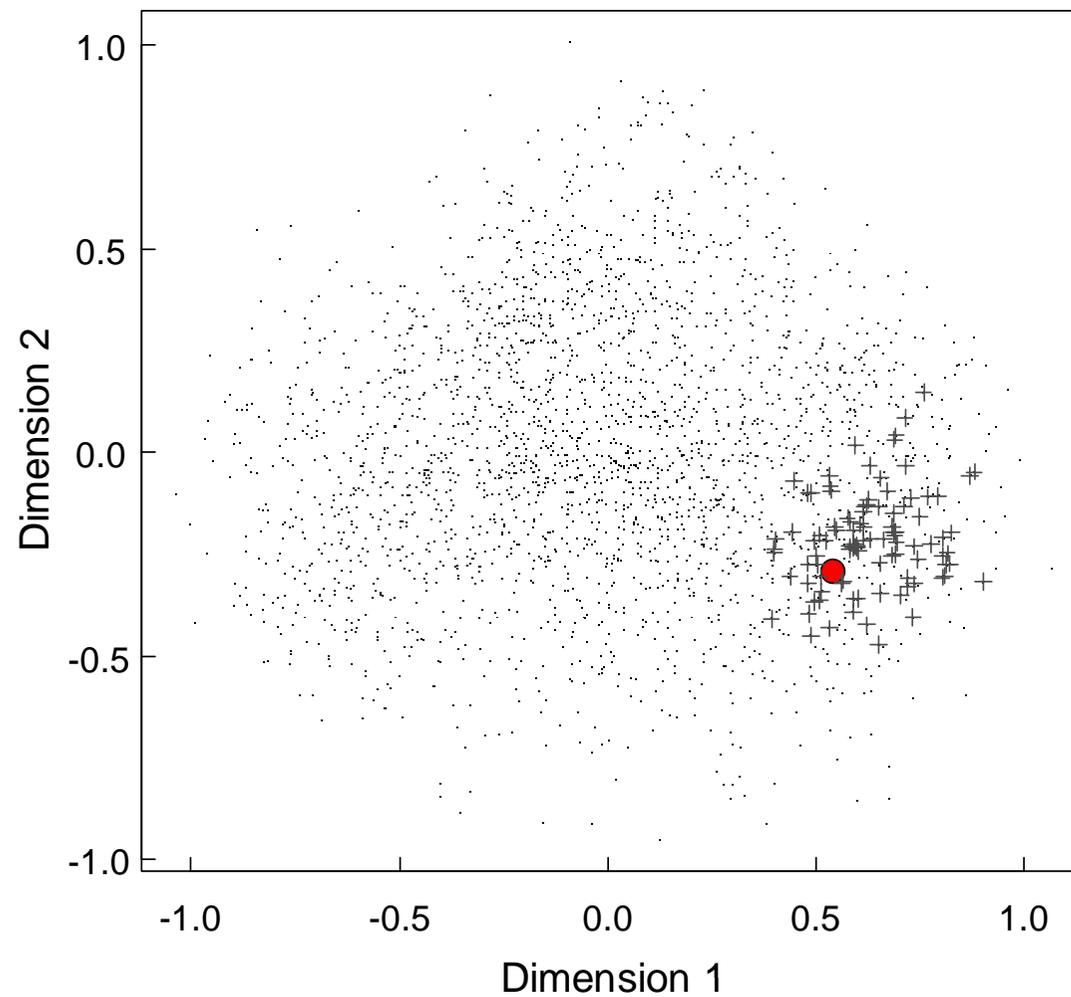
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Species richness vs. heterogeneity



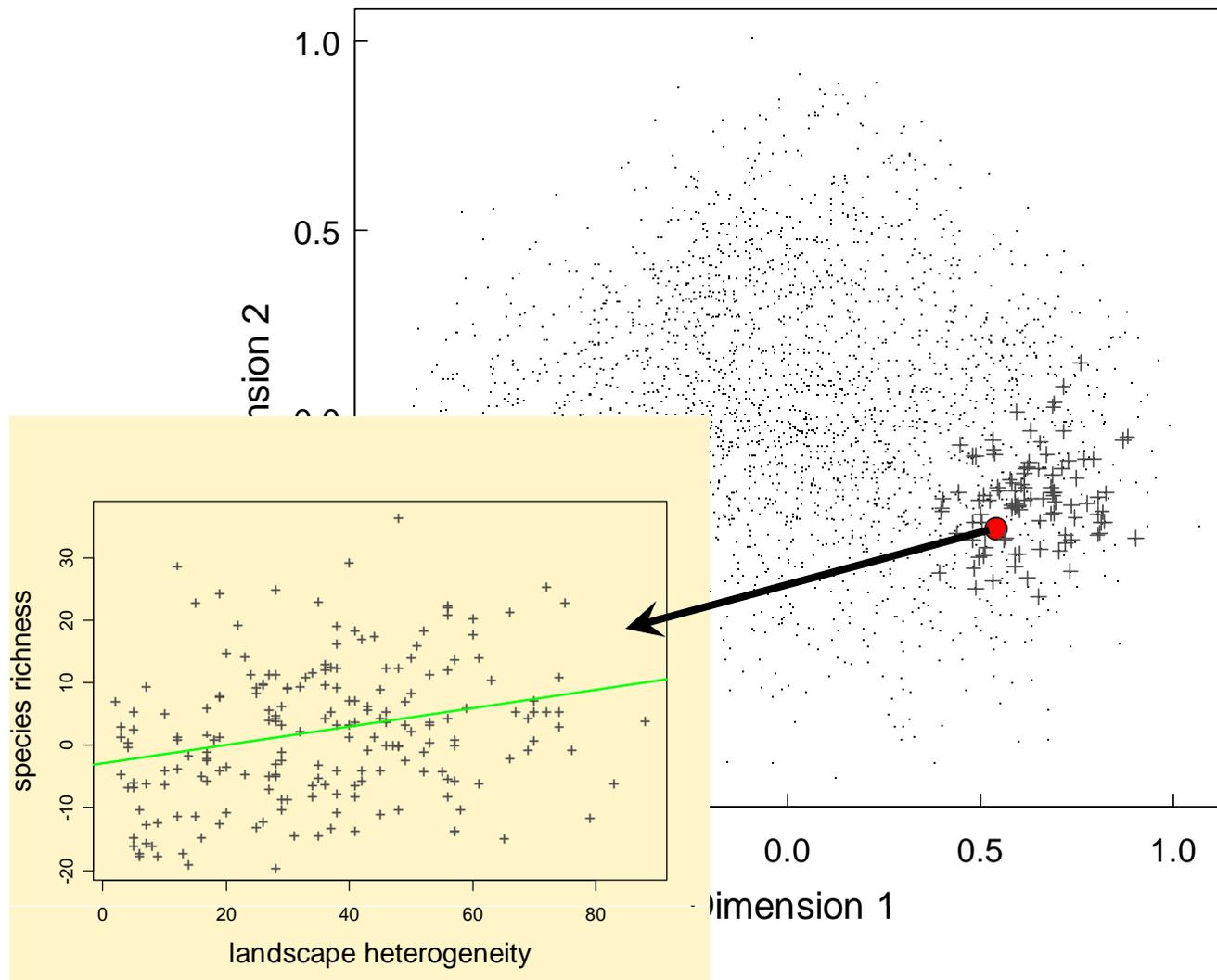
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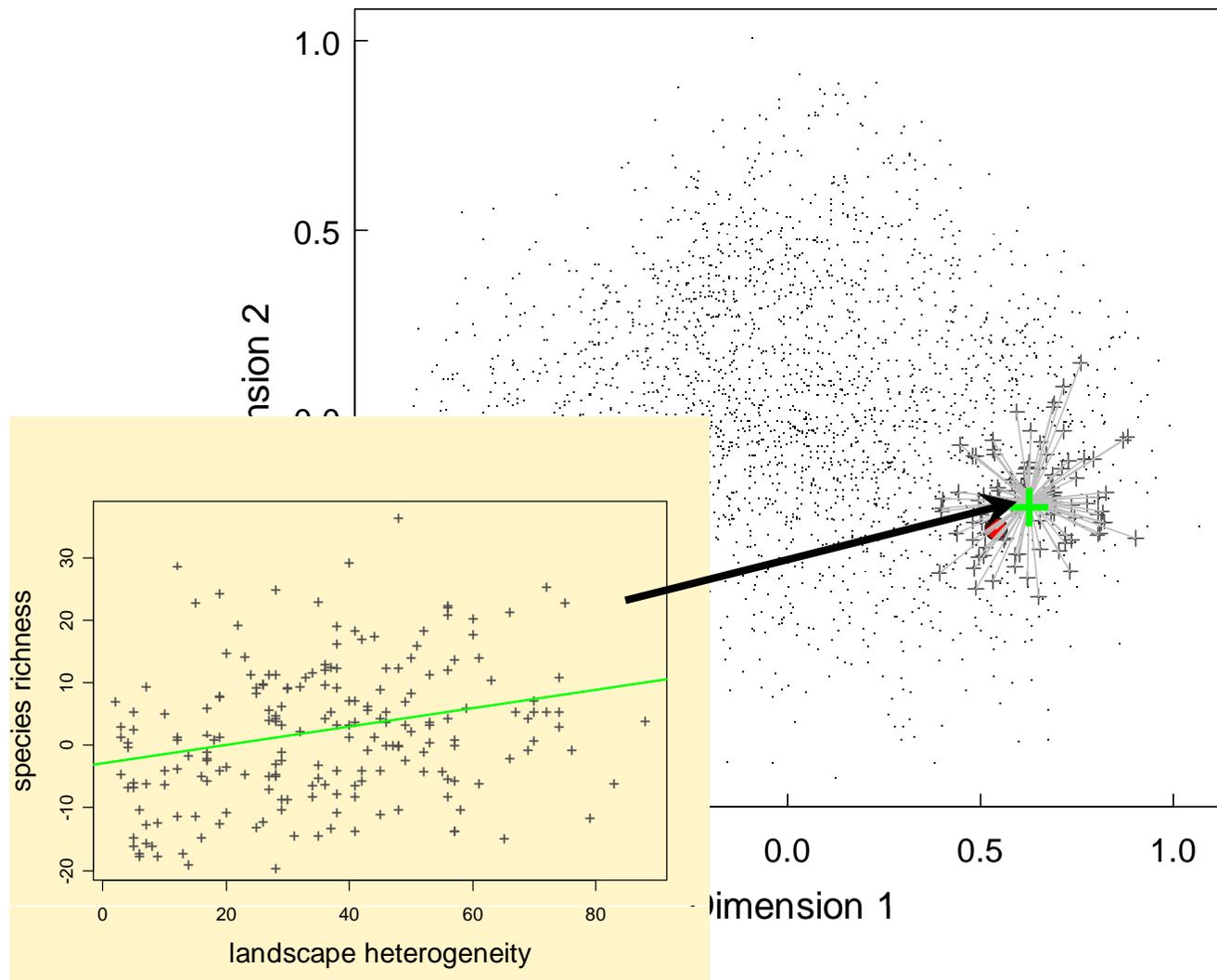
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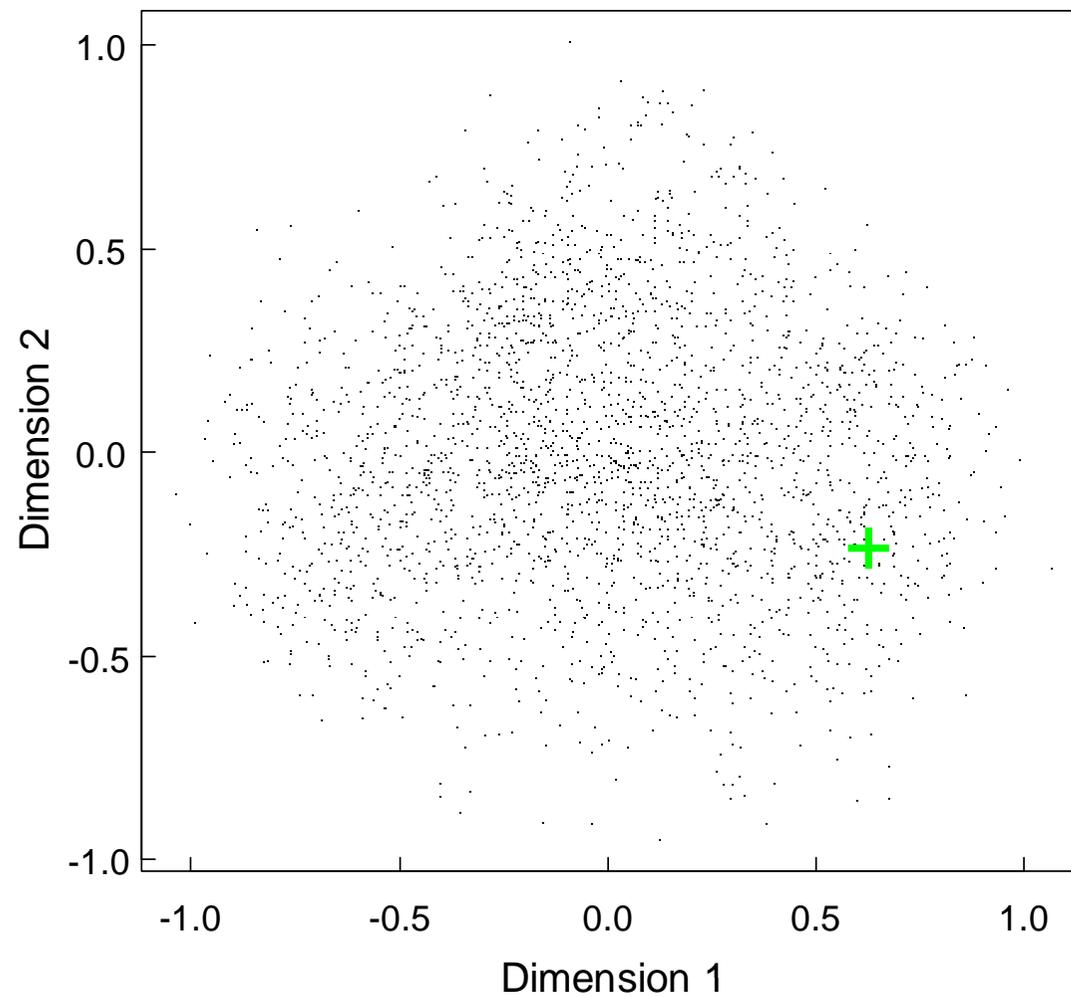
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Species richness vs. heterogeneity



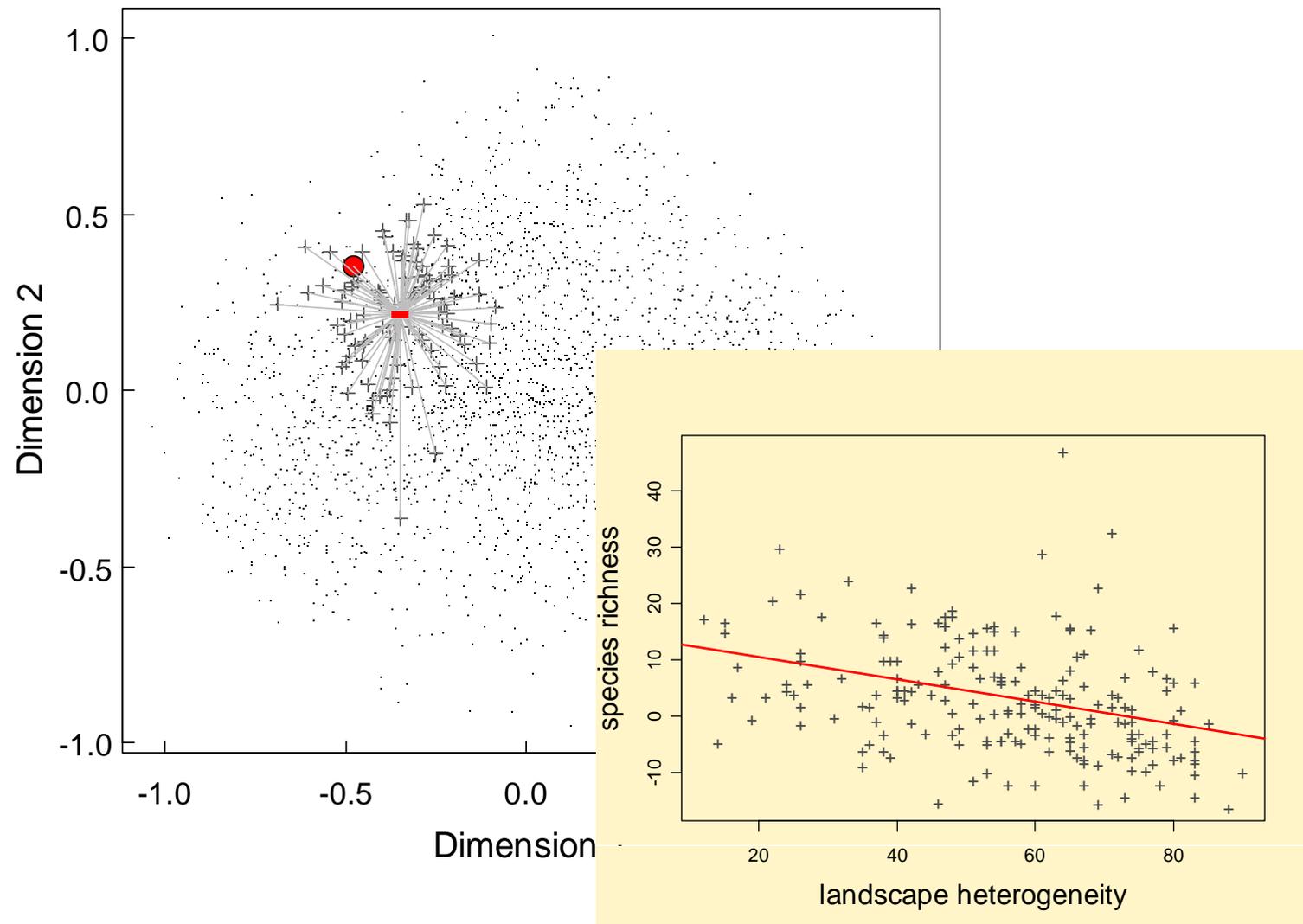
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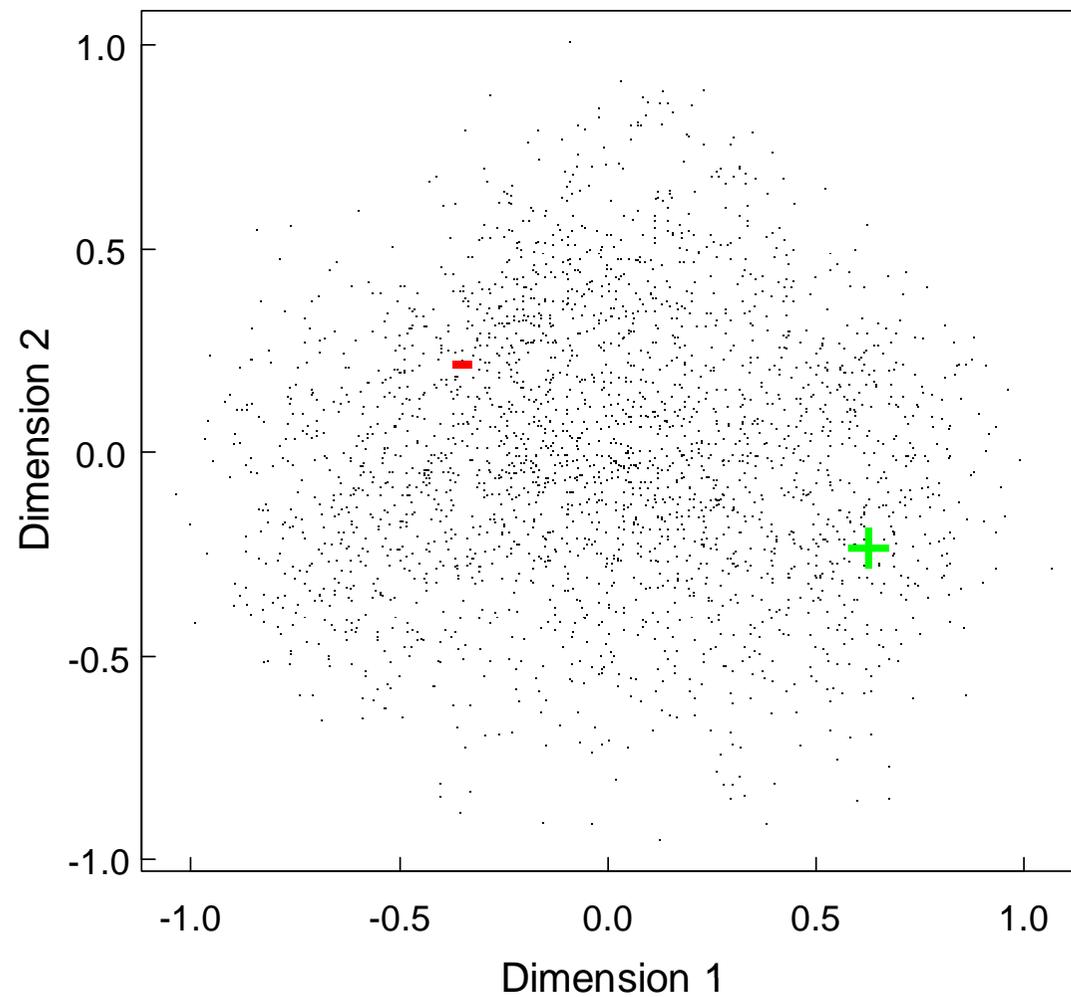
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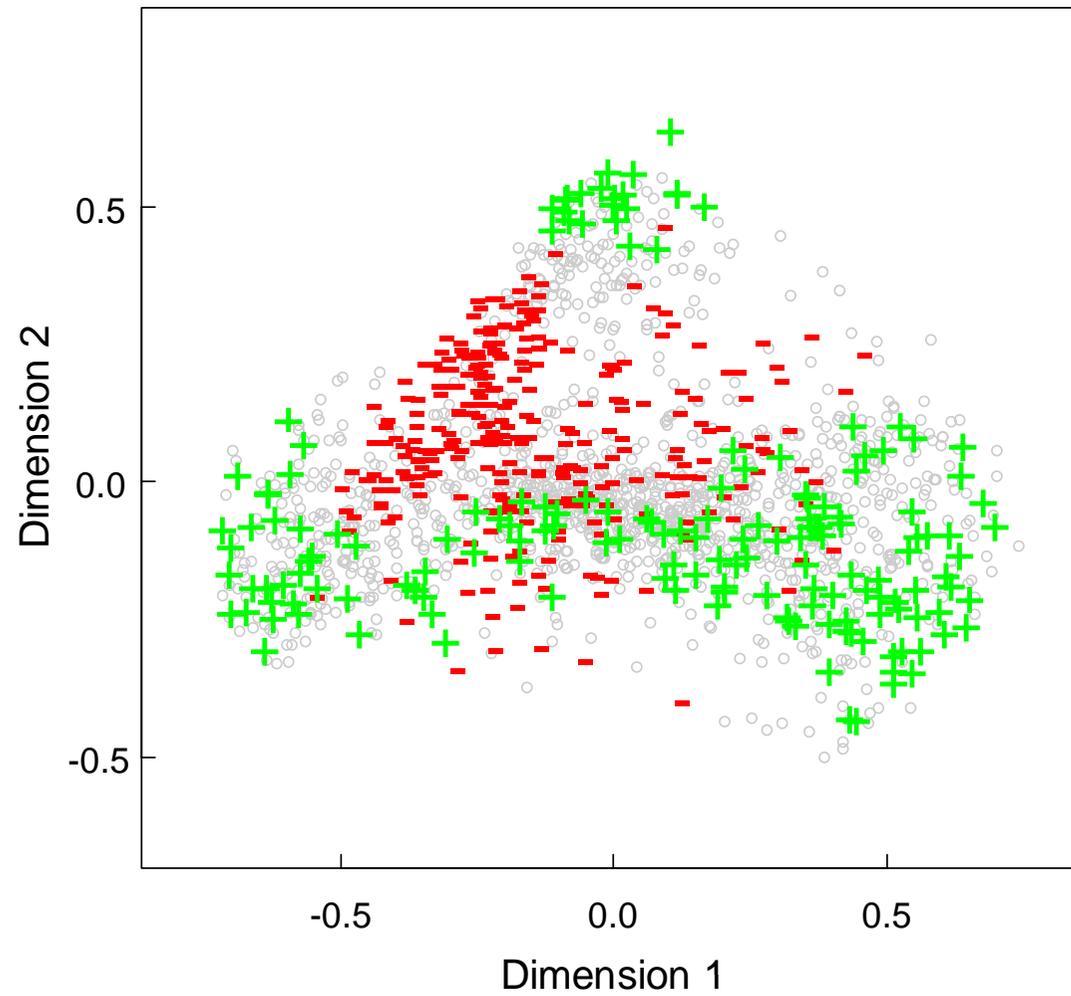
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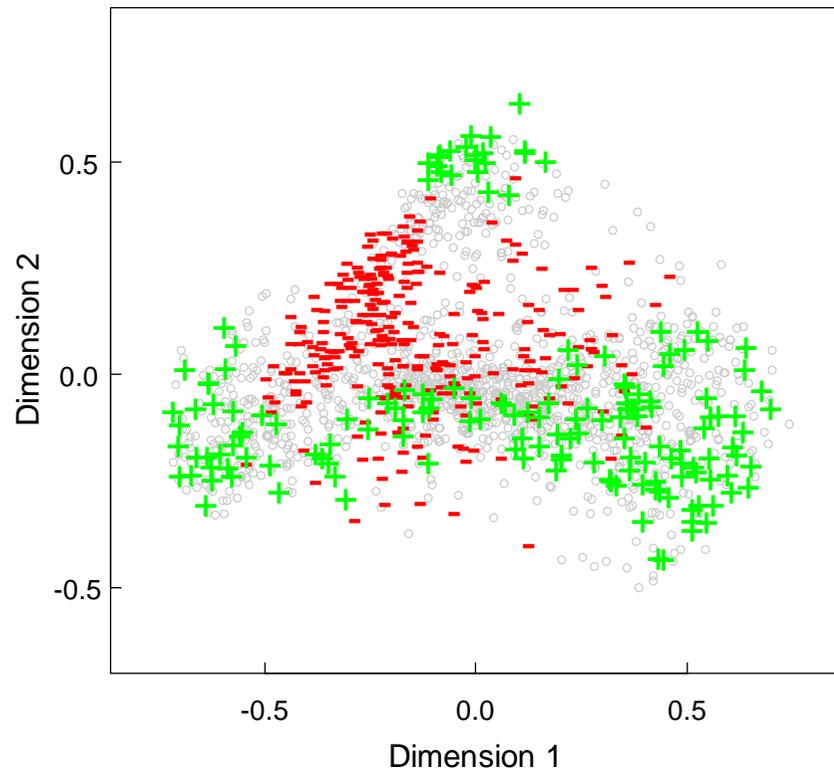
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Species richness vs. heterogeneity

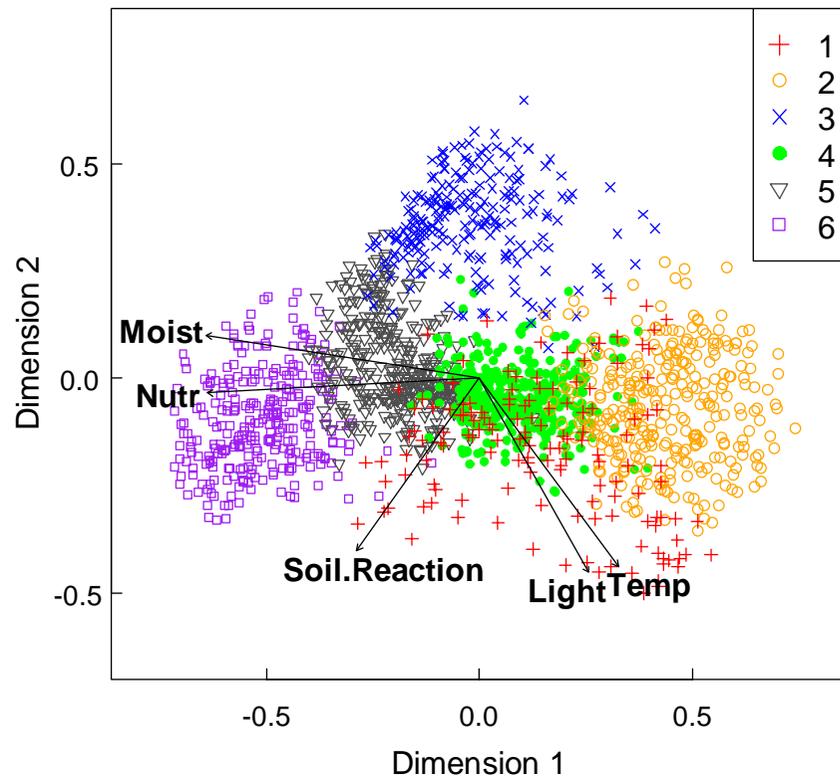


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Species richness vs. heterogeneity

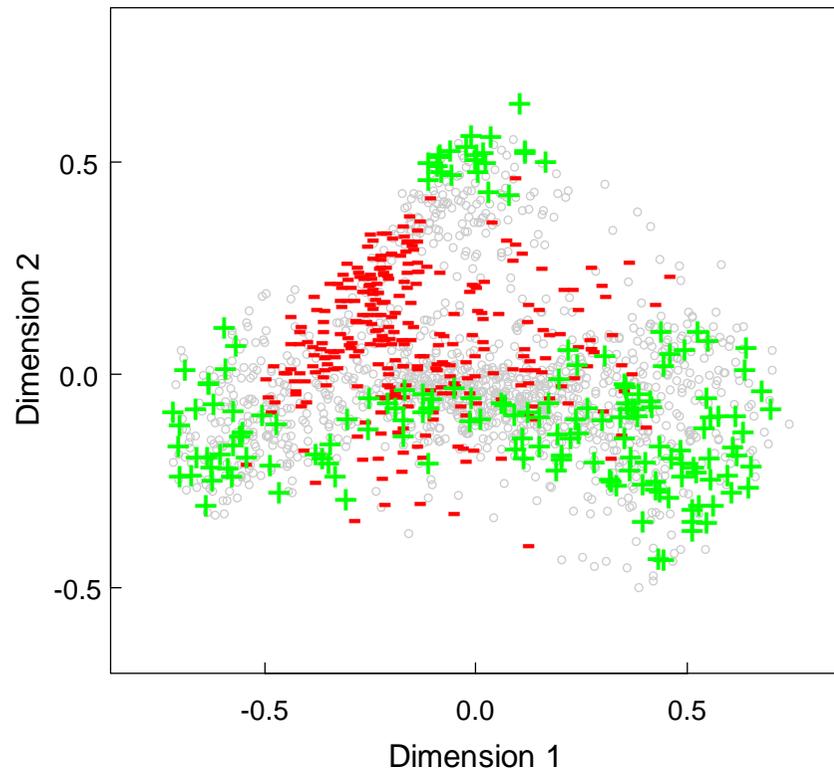


Vegetation types

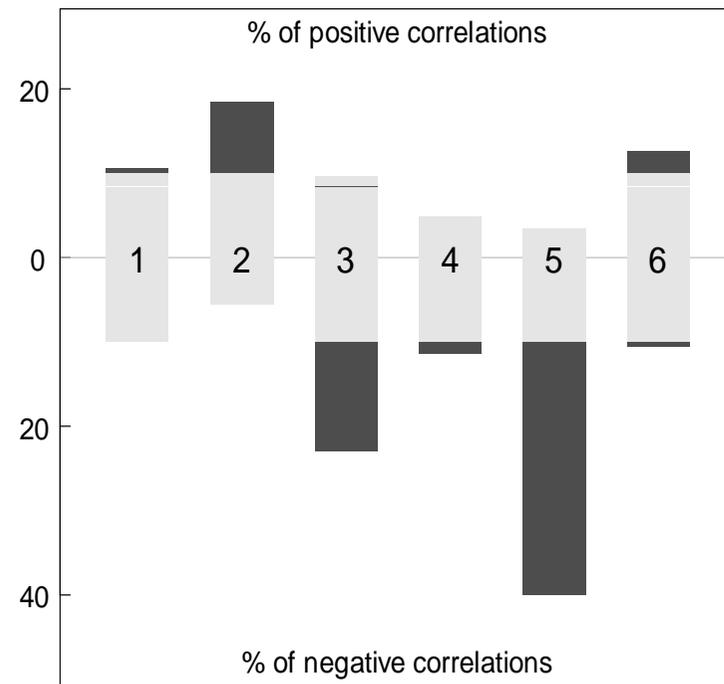


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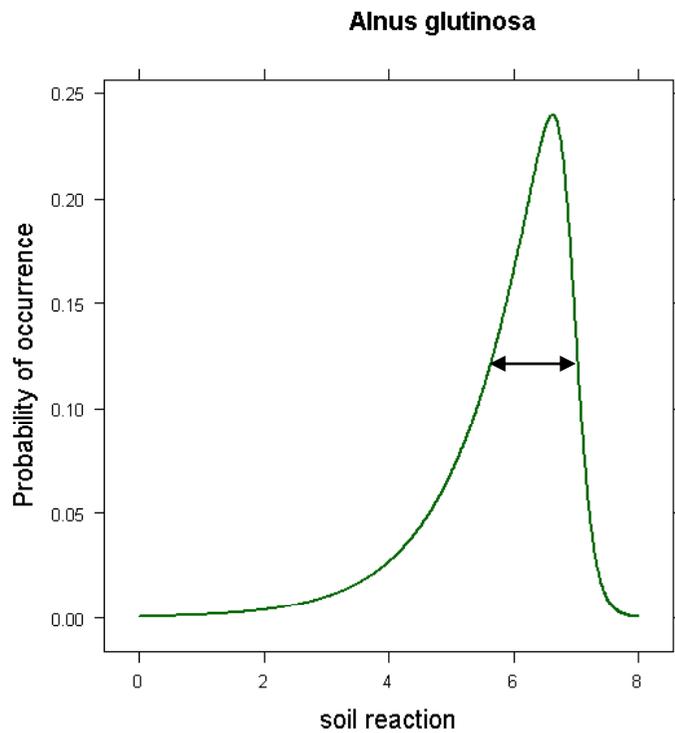


Species richness vs. heterogeneity

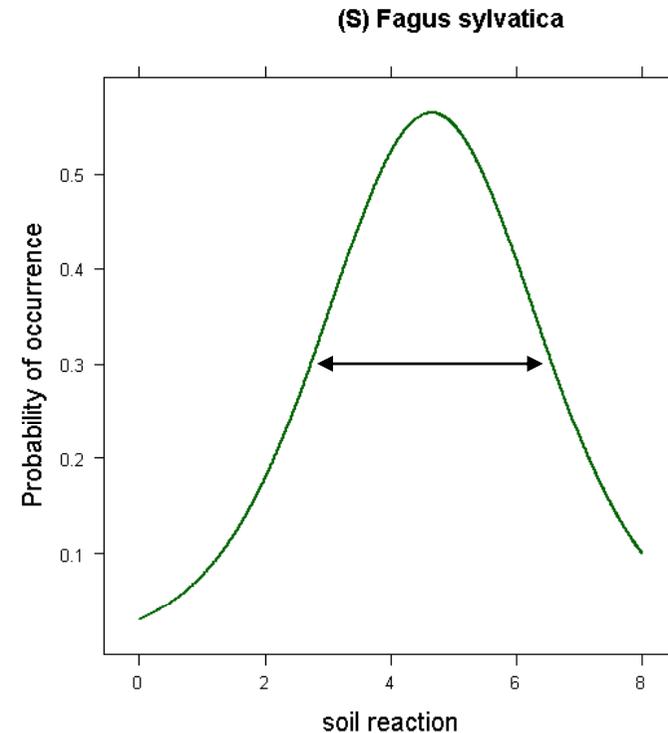


Zelený D. , Li Ch.-F. & Chytrý M. (submitted): Pattern of plant species richness along the gradient of landscape topographic heterogeneity: result of spatial mass effect or environmental shift?

Species habitat specialization based on the species niche width along environmental gradient

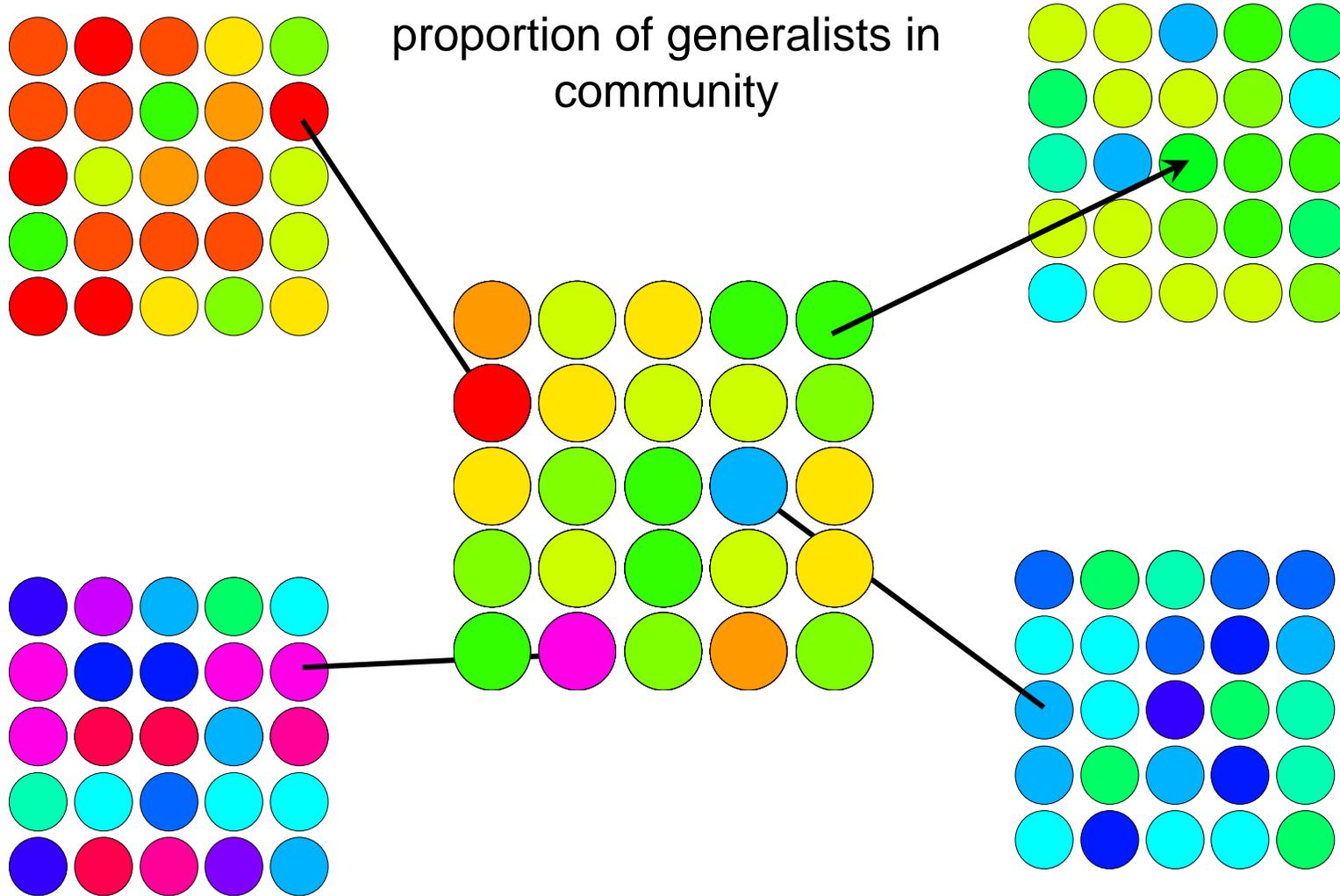


specialist
=
species with
narrow niche



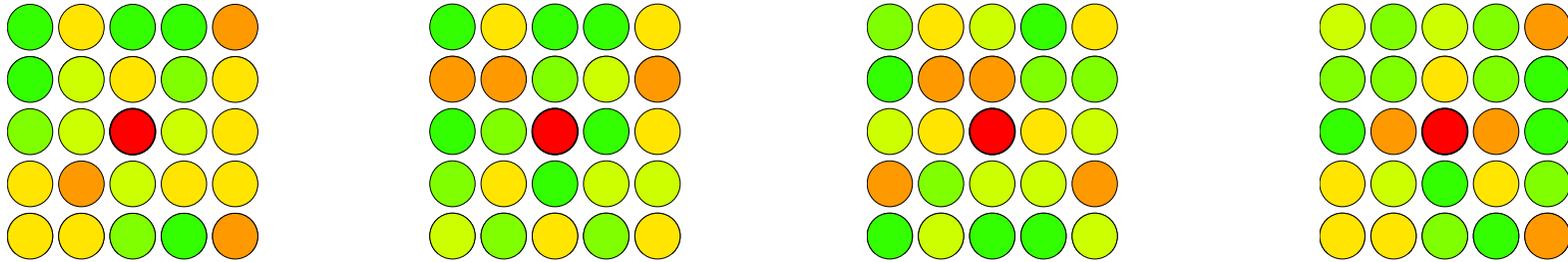
generalist
=
species with
wide niche

Steiner & Köhler (2003) –
spatial mass effect
increases with increased
proportion of generalists in
community

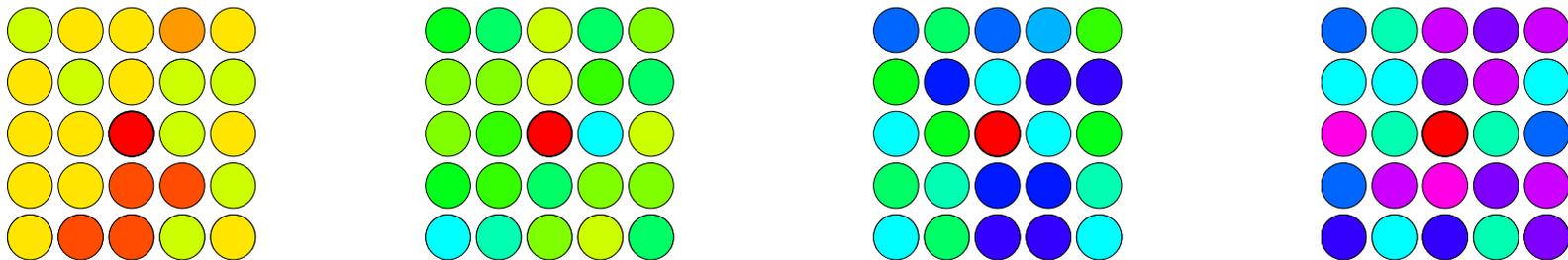


Steiner & Köhler (2003): Effects of landscape patterns on species richness – a modelling approach. – *Agriculture, Ecosystems and Environment*, 98: 353-361.

Species habitat specialization based on the compositional differences among occupied habitats

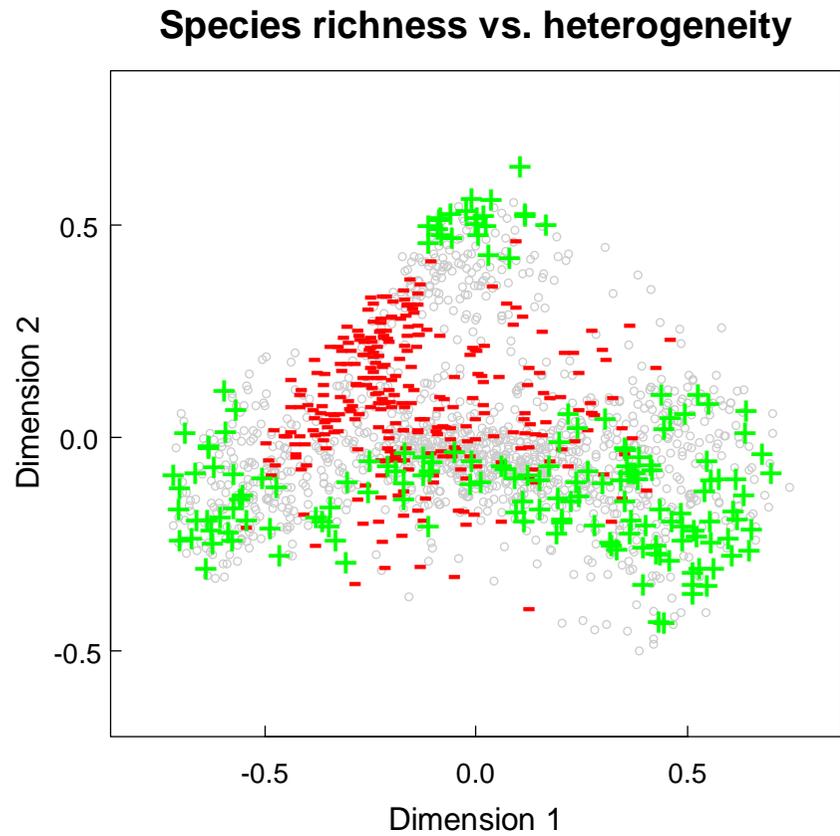


specialist – occurs in **similar** habitats with **similar** species composition

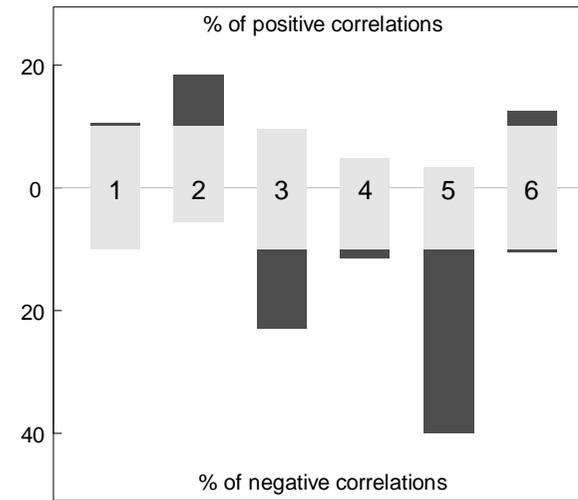


generalist – occurs in **various** habitats with **diverse** species composition

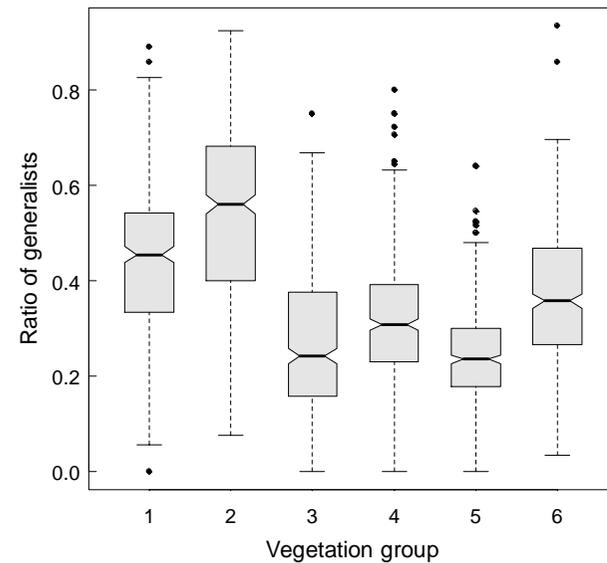
Fridley et al. (2007): Co-occurrence based assessment of habitat generalists and specialists: a new approach for the measurement of niche width. *Journal of Ecology*, **95**, 707-722.



Species richness vs. heterogeneity

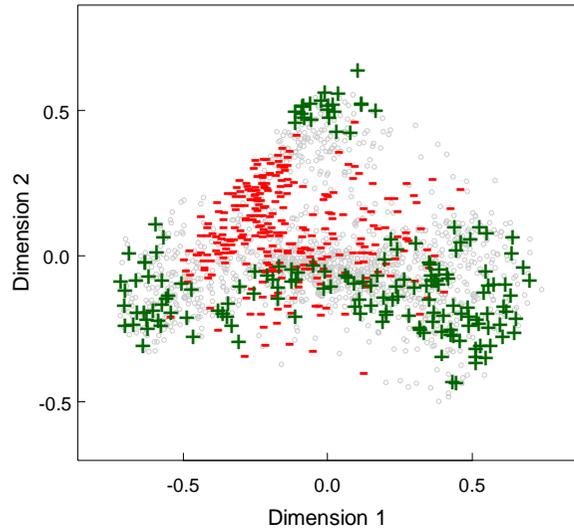


Ratio of generalists per vegetation type

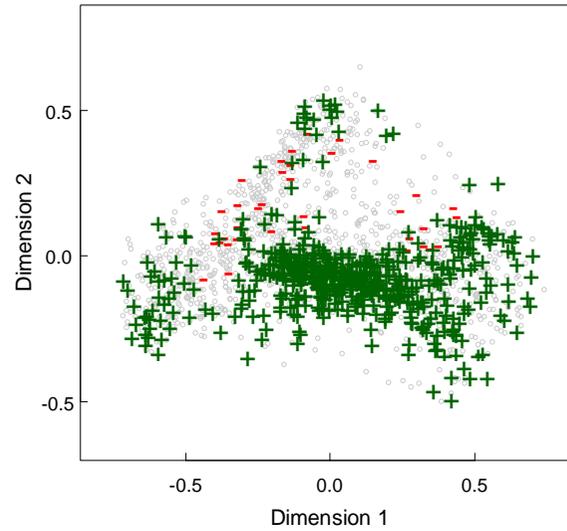


Zelený D. , Li Ch.-F. & Chytrý M. (submitted): Pattern of plant species richness along the gradient of landscape topographic heterogeneity: result of spatial mass effect or environmental shift?

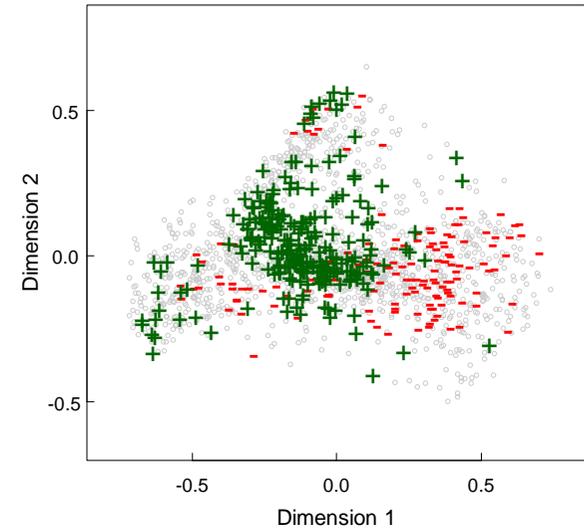
Species richness vs. heterogeneity



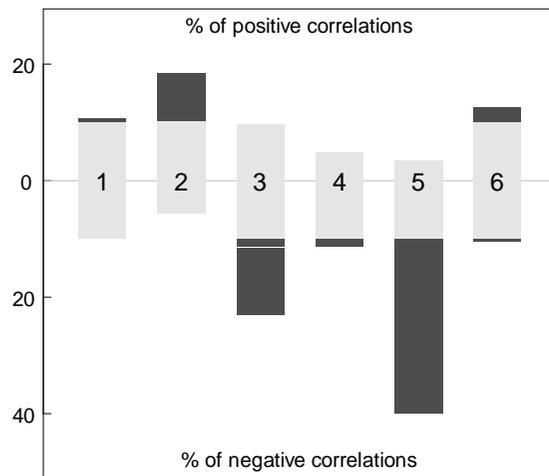
Soil reaction vs. heterogeneity



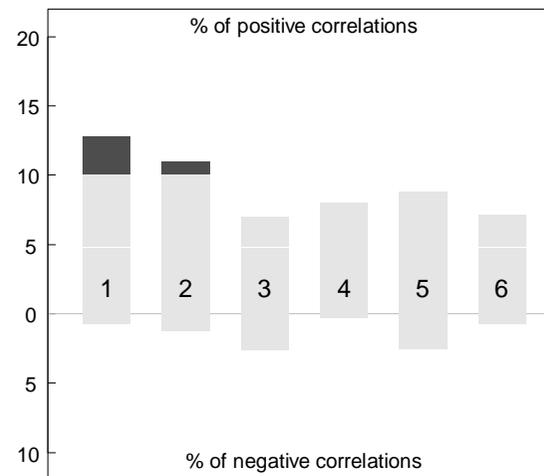
Nutrients vs. heterogeneity



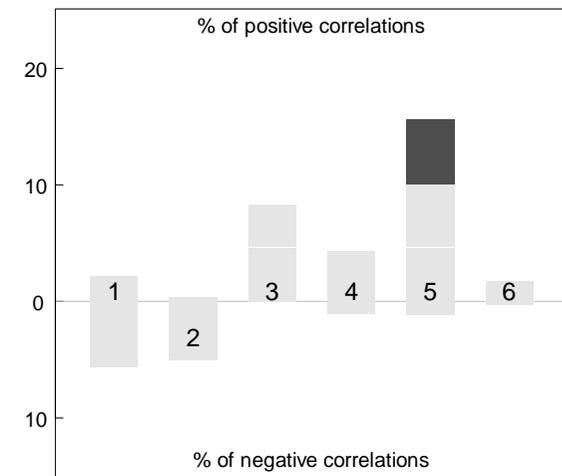
Species richness vs. heterogeneity



Soil reaction vs. heterogeneity

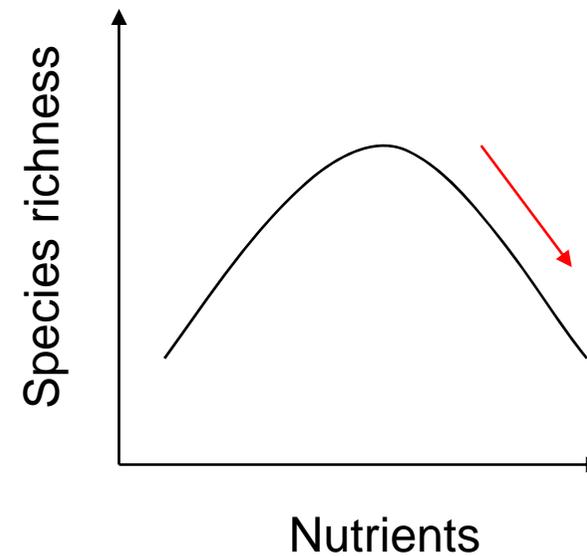
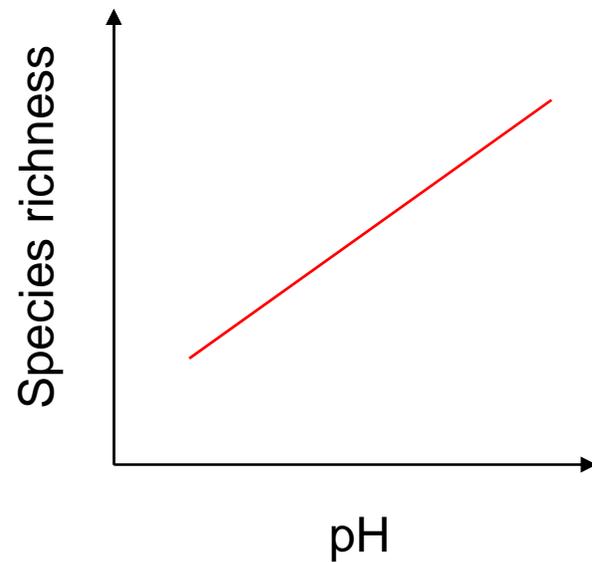


Nutrients vs. heterogeneity



Zelený D. , Li Ch.-F. & Chytrý M. (submitted): Pattern of plant species richness along the gradient of landscape topographic heterogeneity: result of spatial mass effect or environmental shift?

Empirical models of species richness along gradients of soil reaction and nutrients



Paper 3: Conclusions

1. Generally, nutrient-poor vegetation types are more species rich in topographically heterogeneous landscape, while the opposite is true for nutrient-rich vegetation types;
2. nutrient-poor vegetation types (e.g. oak forests) have high proportion of habitat generalists, indicating that their higher species richness in heterogeneous landscape may be result of pronounced spatial mass effect;
3. the pattern of local species richness along the gradient of landscape topographical heterogeneity may be also explained by the shifts in stand ecological conditions: at heterogeneous landscape, the stands have higher soil reaction (valid for almost all vegetation types), and also higher productivity (valid only for nutrient-rich vegetation types).

David Zelený

Co-occurrence-based assessment of species habitat specialization is affected by the size of species pool:
reply to Fridley *et al.* (2007).

Journal of Ecology, in press

Main aim: methodological paper, which points up the problem of the method for estimation of species habitat specialization, as originally published by Fridley *et al.* (2007); corrected version is proposed.

Thank you for your attention!

