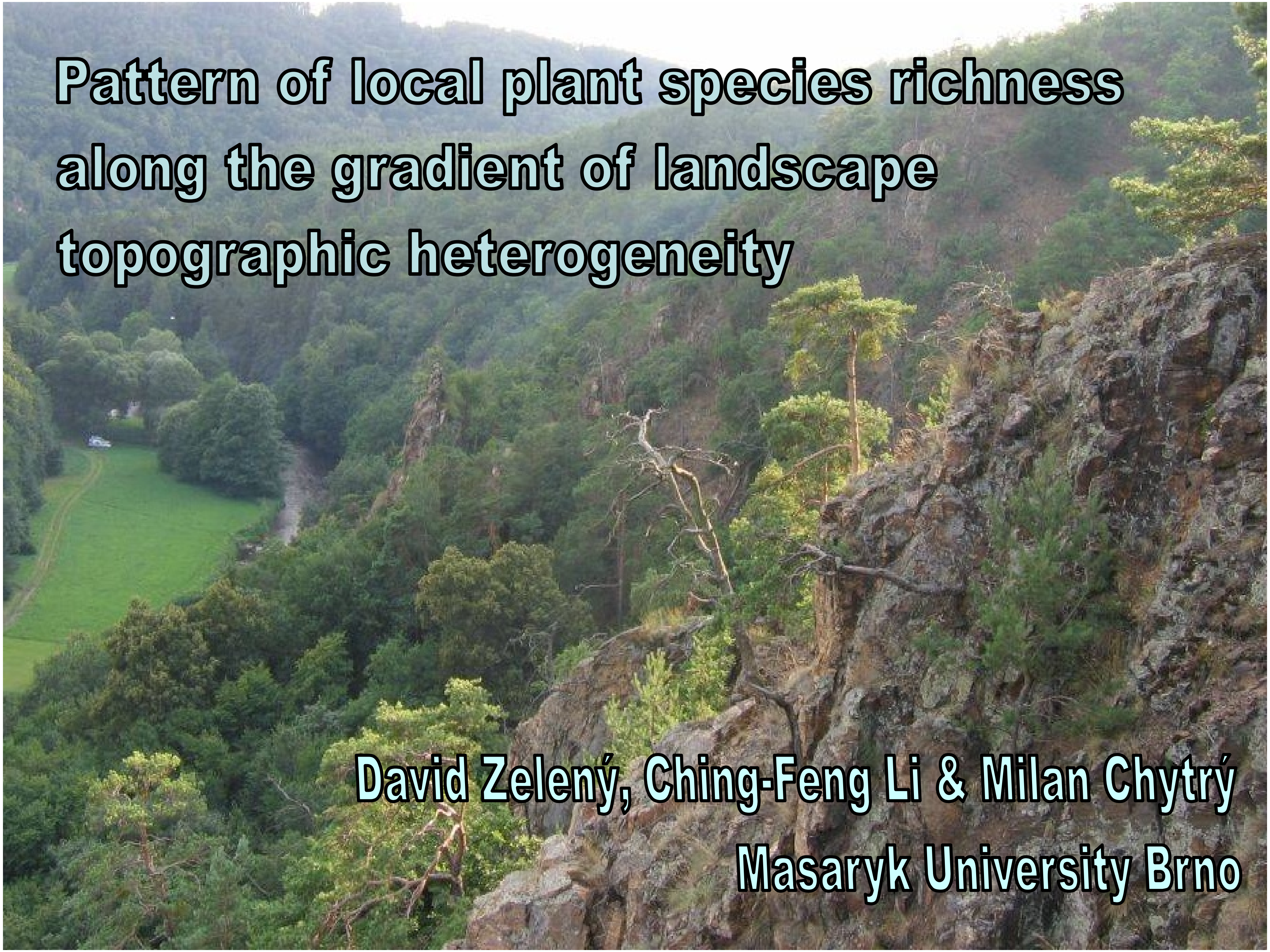

Pattern of local plant species richness along the gradient of landscape topographic heterogeneity

David Zelený, Ching-Feng Li & Milan Chytrý
Masaryk University Brno

European Vegetation Survey, 16th Workshop, Rome (Italy), March 22-26, 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 (0 for the valley bottom, 1 for the upper edge)
SLOPE	slope inclination (°), observed range: Vltava 0–88°, 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 (aspect - 202.5°) × tg SLOPE
SURFACE SL	landform shape in the downslope direction (-1 concave, 0 flat, 1 convex)
SURFACE ISO	landform shape along an isohypse (-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	skeletic and hyperskeletic Leptosols (soils on scree accumulations)
CAMBISOL	Cambisols (well-developed zonal soils)
LITHIC	lithic Leptosols (shallow soils near rock outcrops)

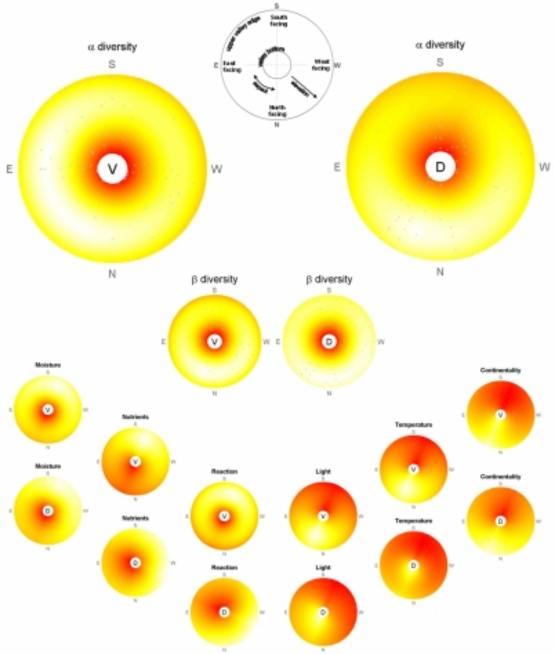


Fig. 2 – Set of 'donut plots' showing spatial distribution of α- and β-diversity and Ellenberg indicator values in an idealized model of deep river valley. Surface is modeled using GLM and drawn in reversed heat colors (red = high values, white = low values). V = Vltava valley, D = Dyje valley.

Results

1) 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.

2) 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 Vltava 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 Vltava valley and linear response in the Dyje valley), and by measure of southerness (Vltava) or heat index (Dyje).

3) 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.

Poster can be found on: http://sci.muni.cz/botany/zeleny/poster-EVS-07.pdf. This study was supported by the long-term research plan MSM0021622416 and its results are part of PhD study of D.Z. The name 'donut plot' was invented by Ching-Feng Li (Woody).

David Zelený, Ching-Feng Li & Milan Chytrý

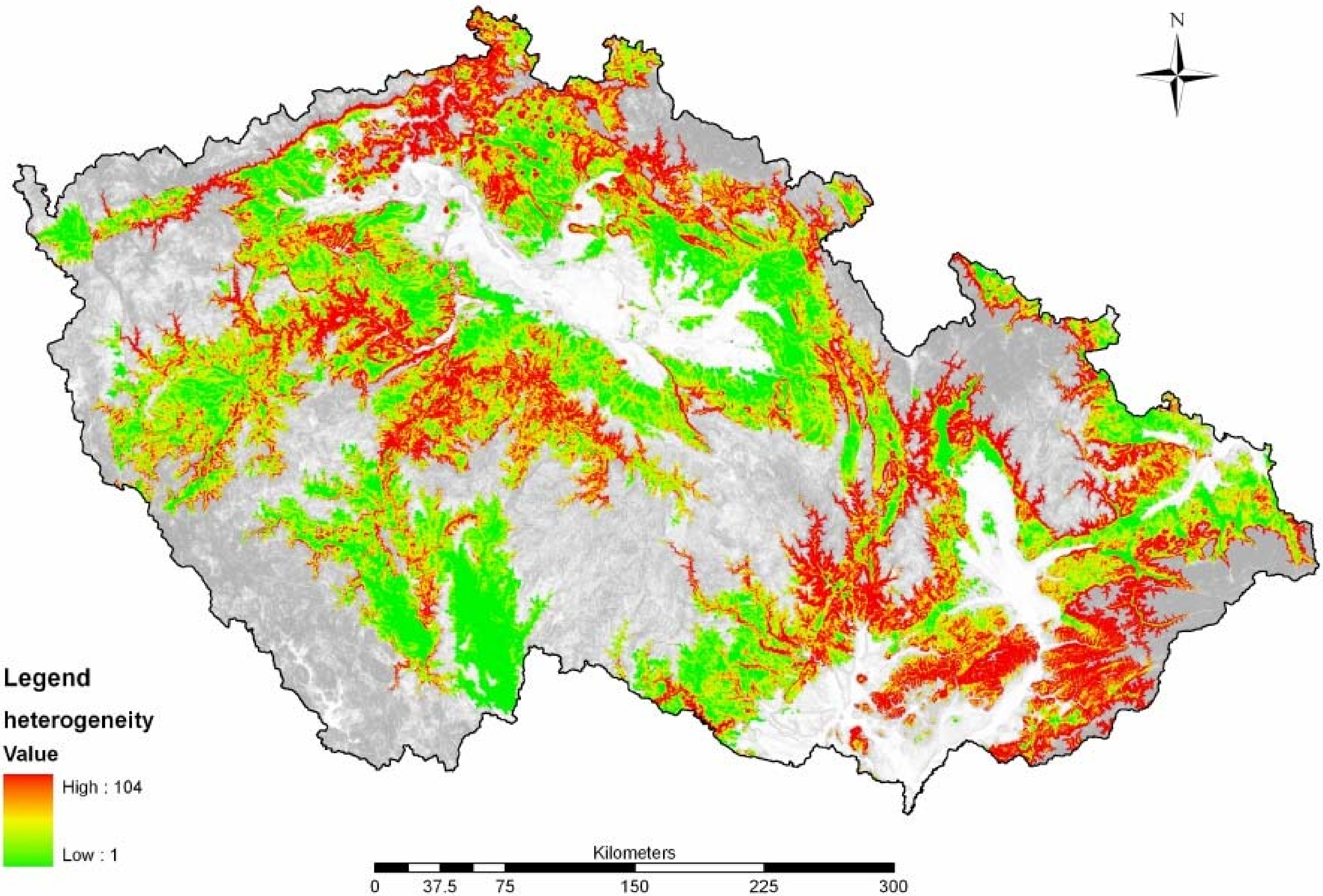
Pattern of plant species richness along the gradient of landscape topographic heterogeneity: result of spatial mass effect or shift in microsite environmental conditions?

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

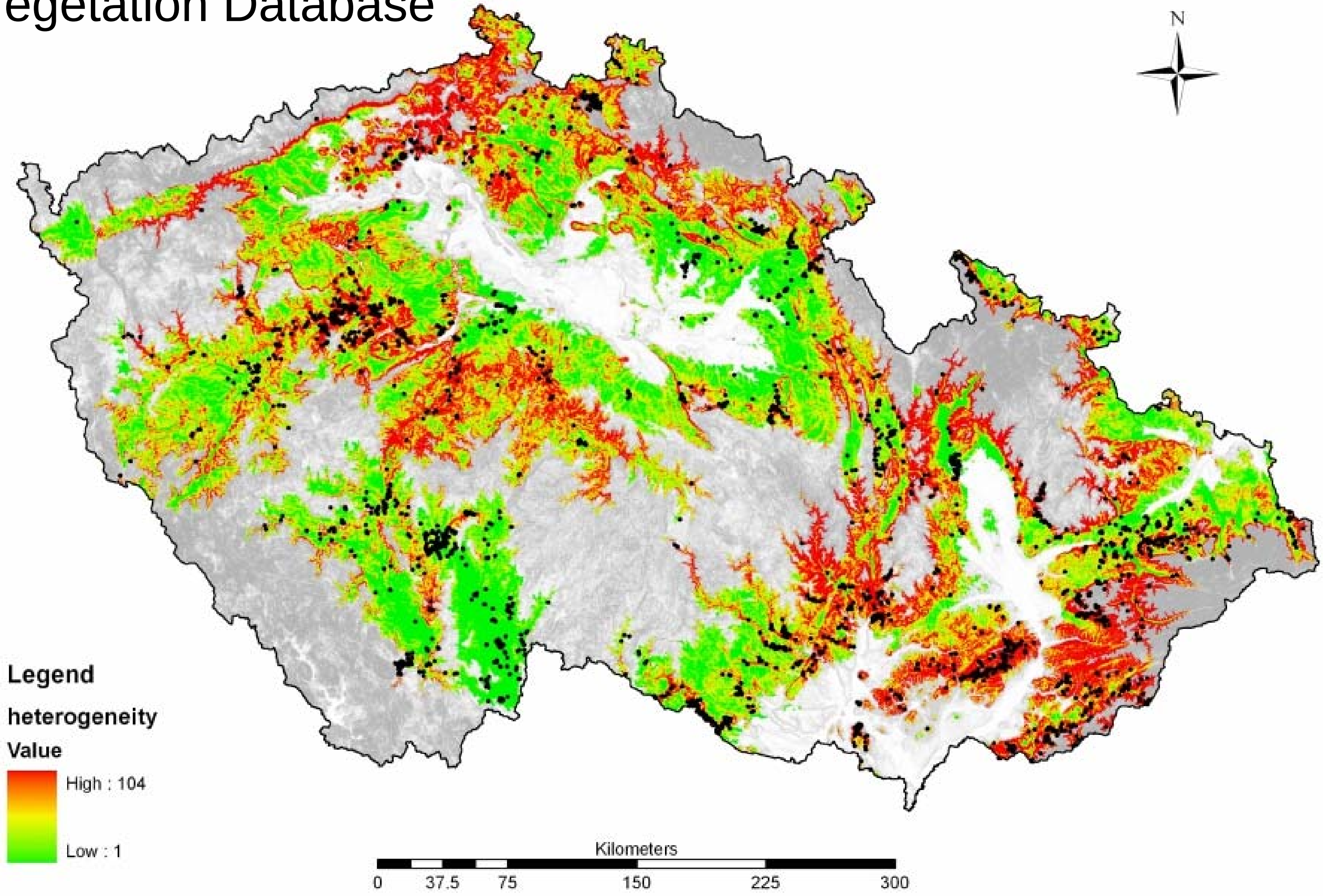
Study area: Czech Republic, 250-480 m a.s.l.

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

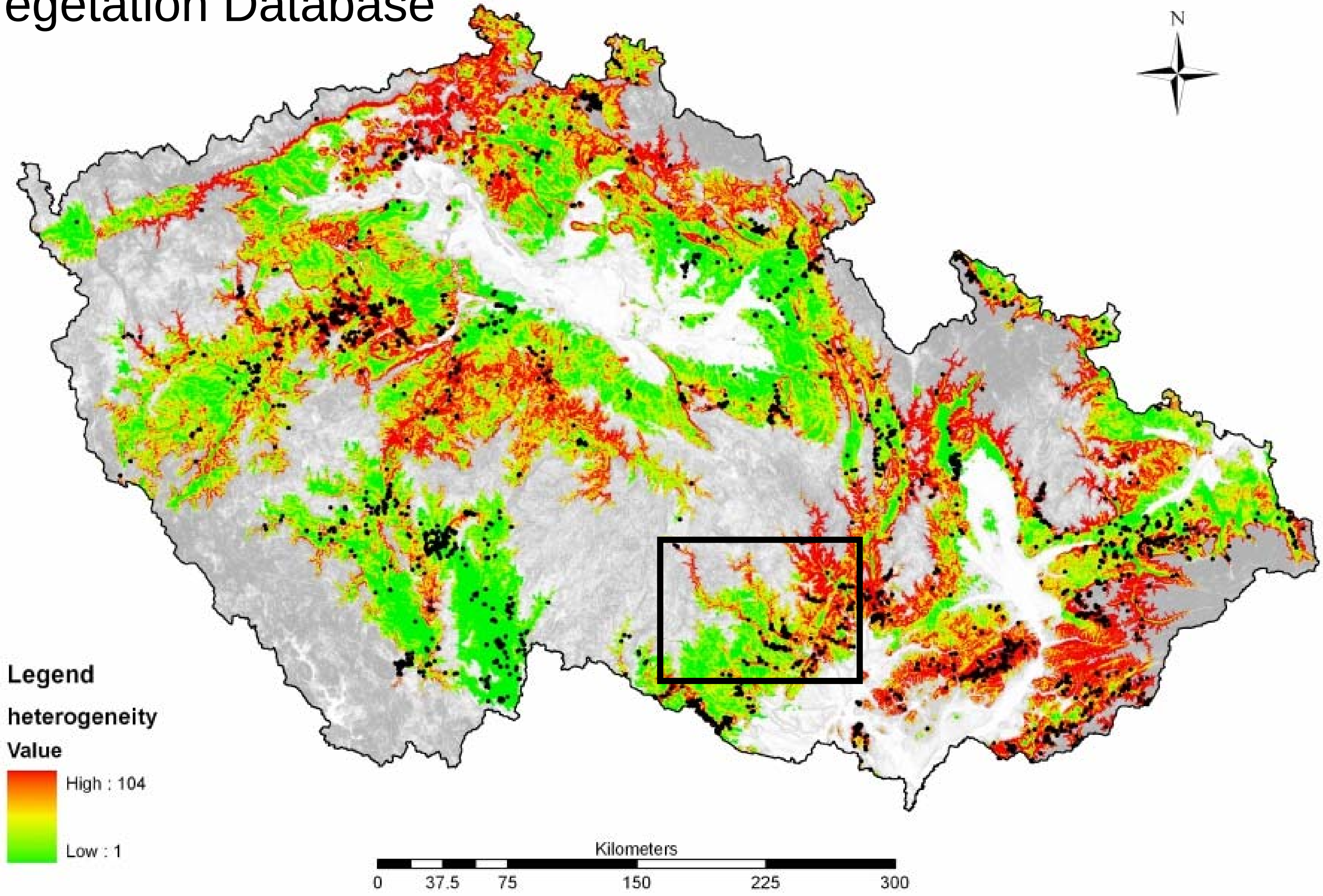
Topographic heterogeneity within the Czech Republic (250-480 m a.s.l.)

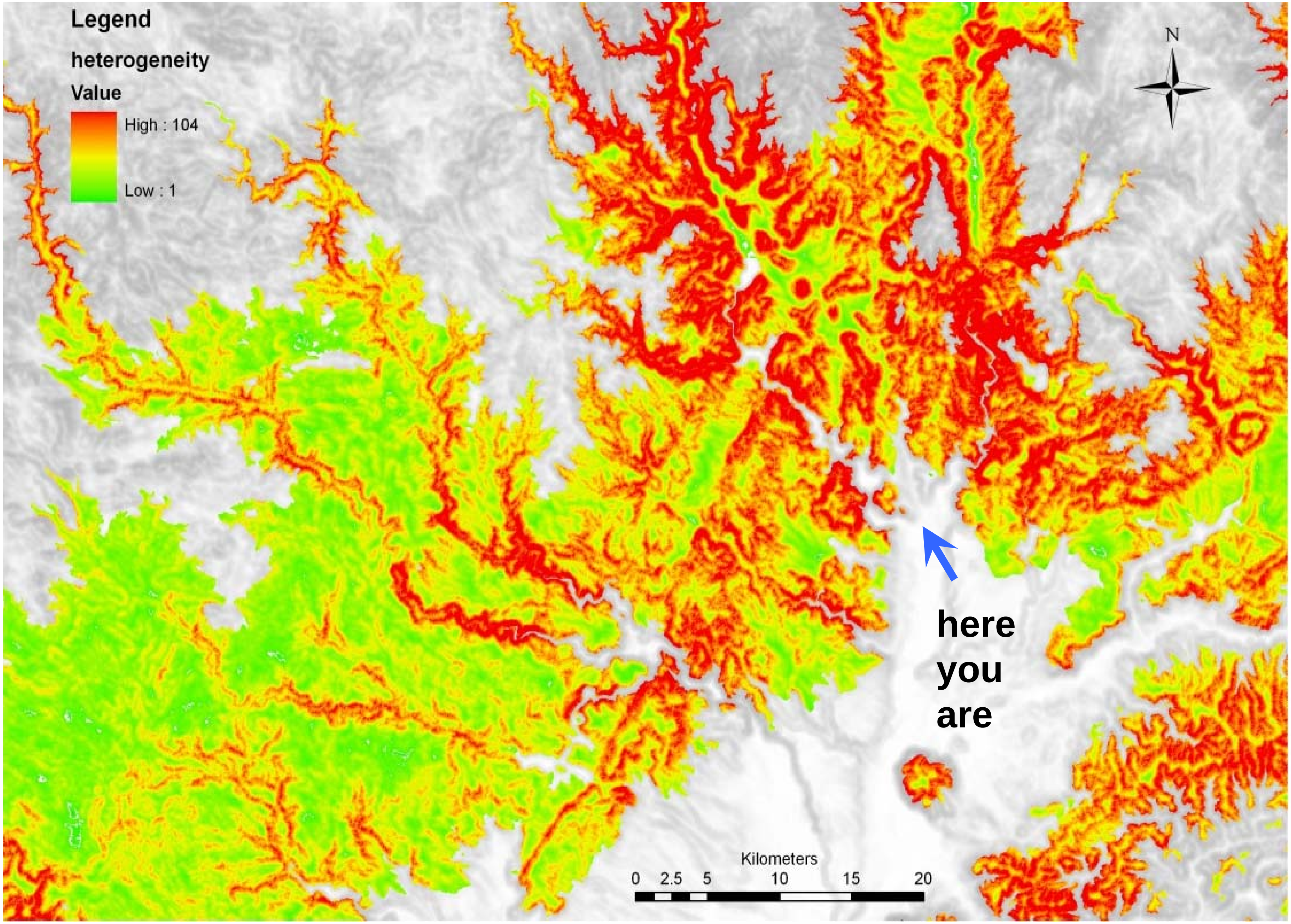


2551 forest vegetation relevés from Czech National Vegetation Database



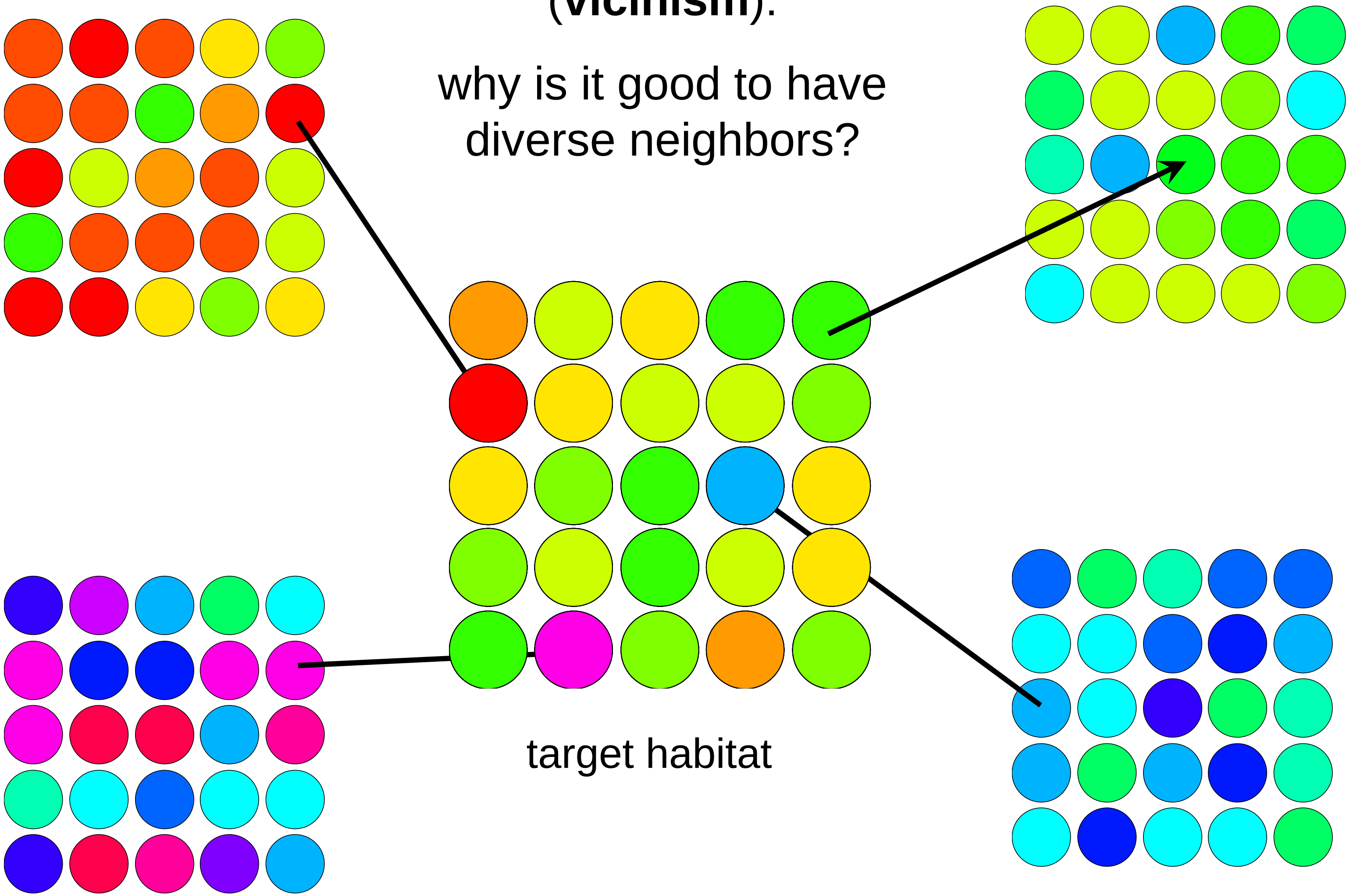
2551 forest vegetation relevés from Czech National Vegetation Database

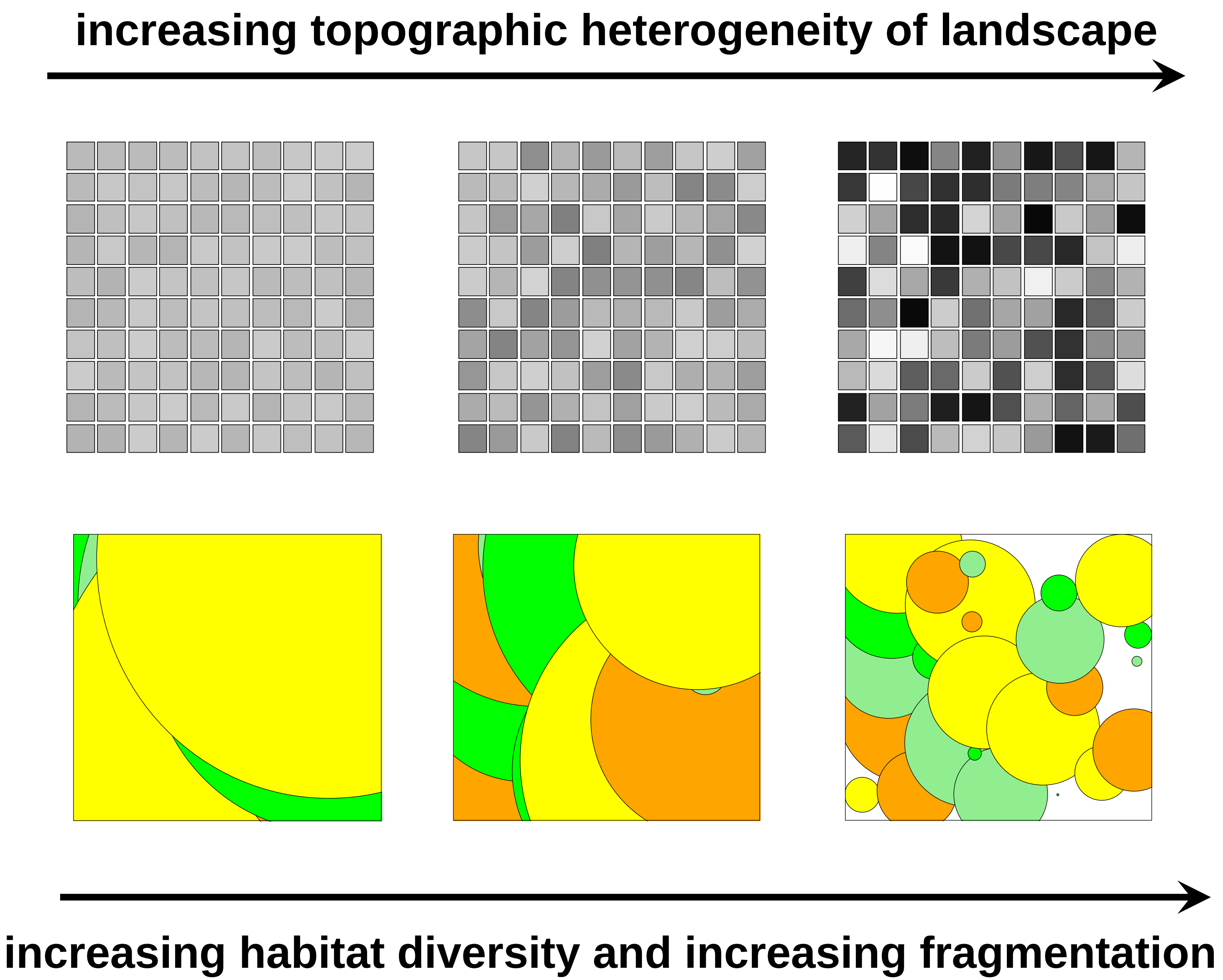


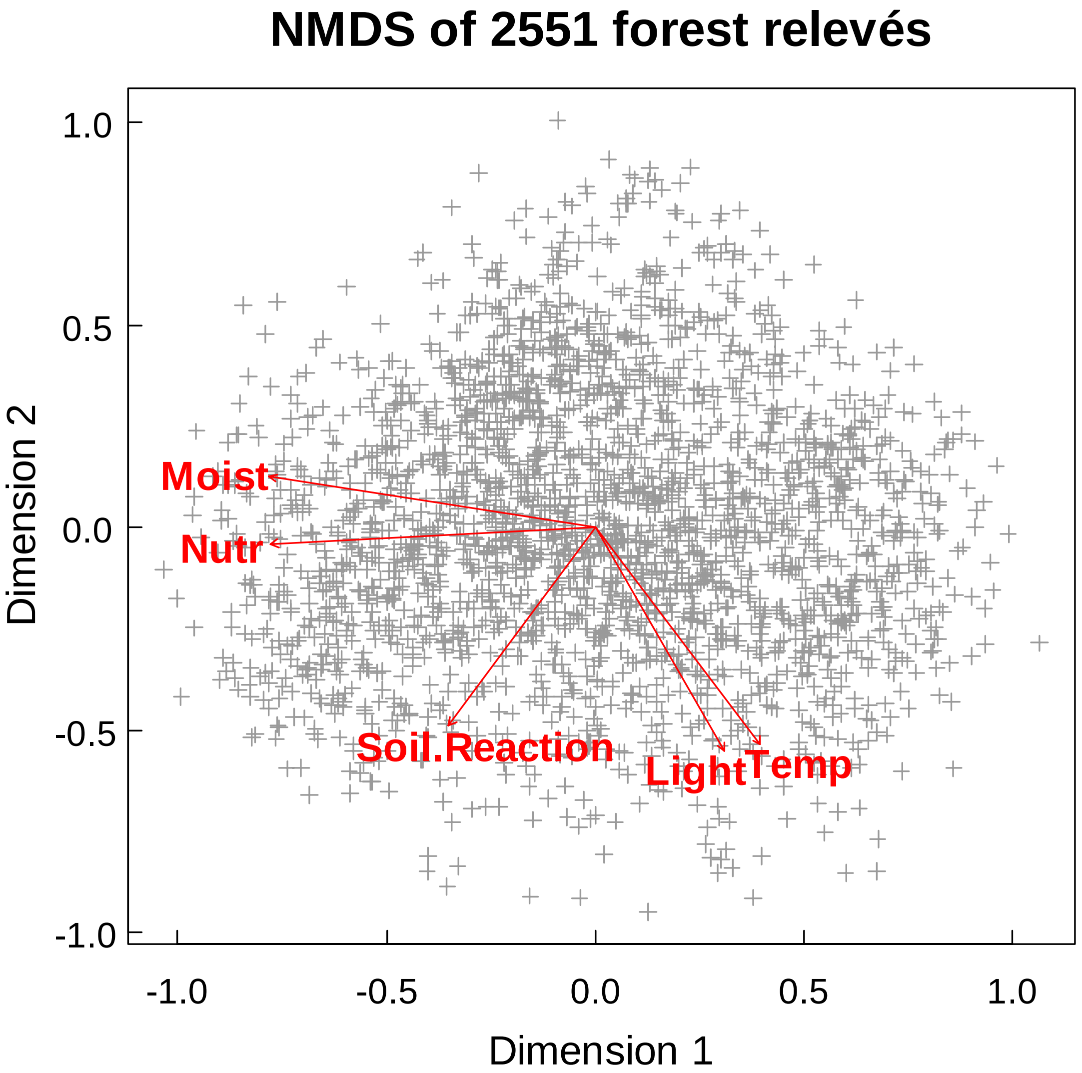

Legend
heterogeneity
Value
High : 104
Low : 1
N
here
you
are
Kilometers
0 2.5 5 10 15 20

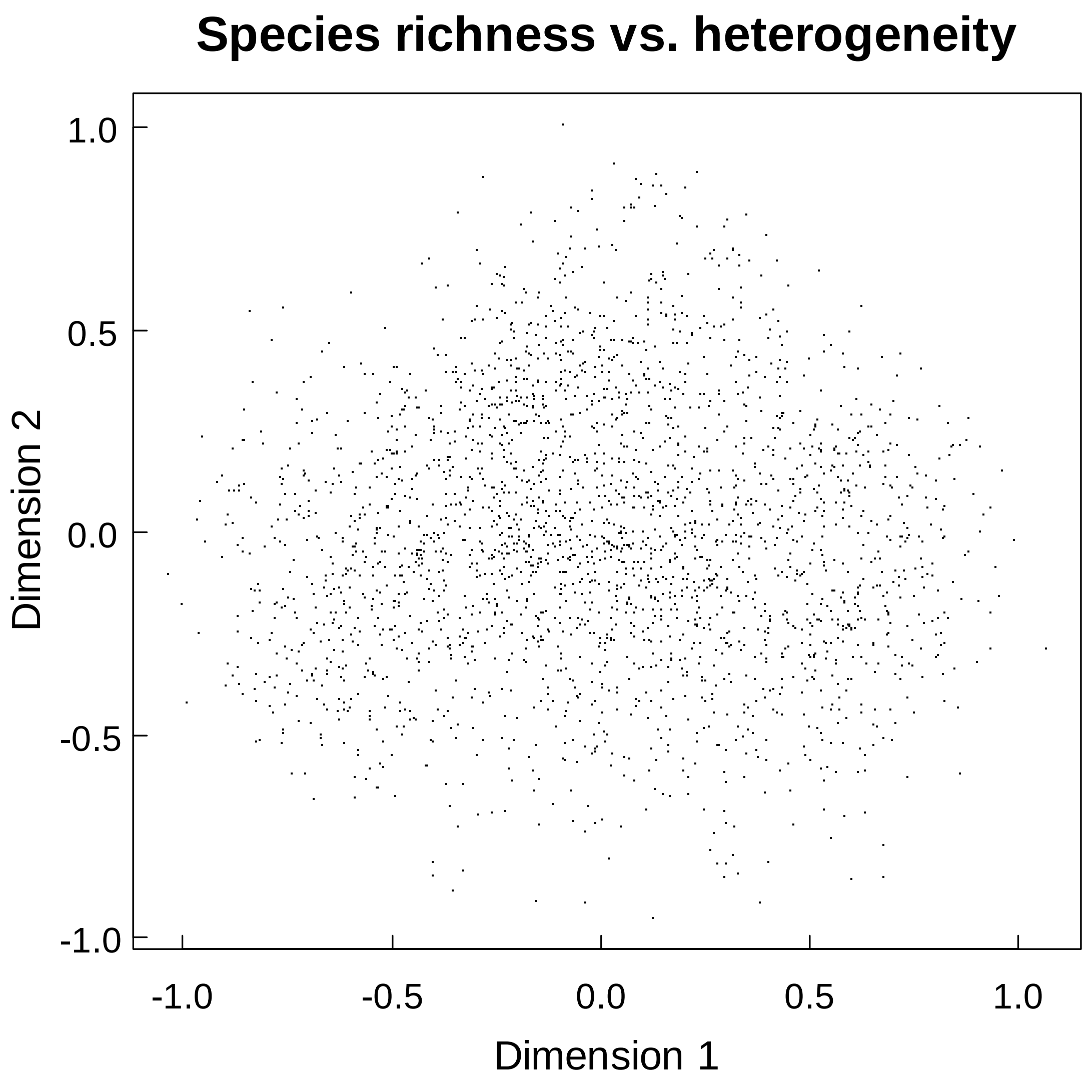
Spatial mass effect (vicinism):

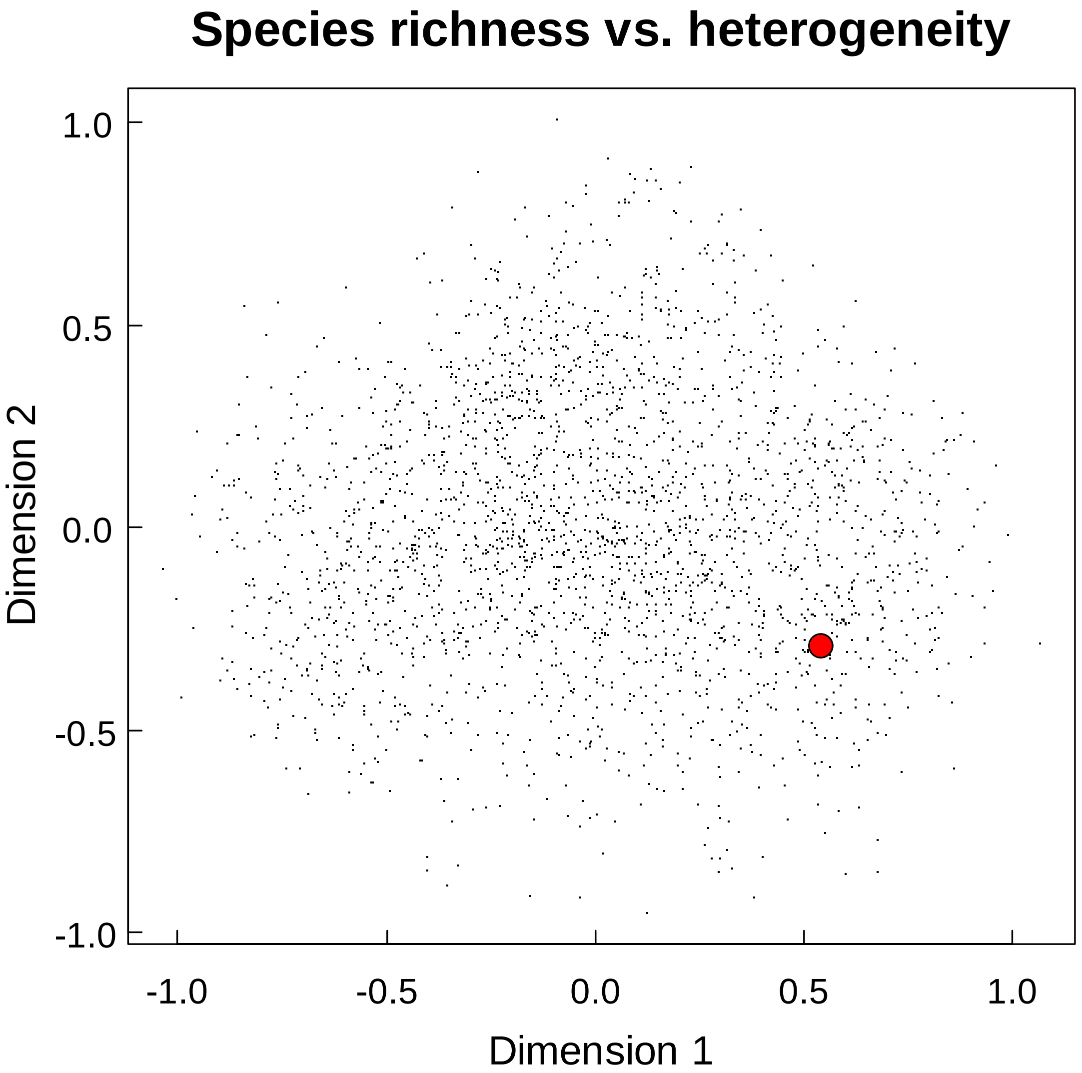
why is it good to have diverse neighbors?



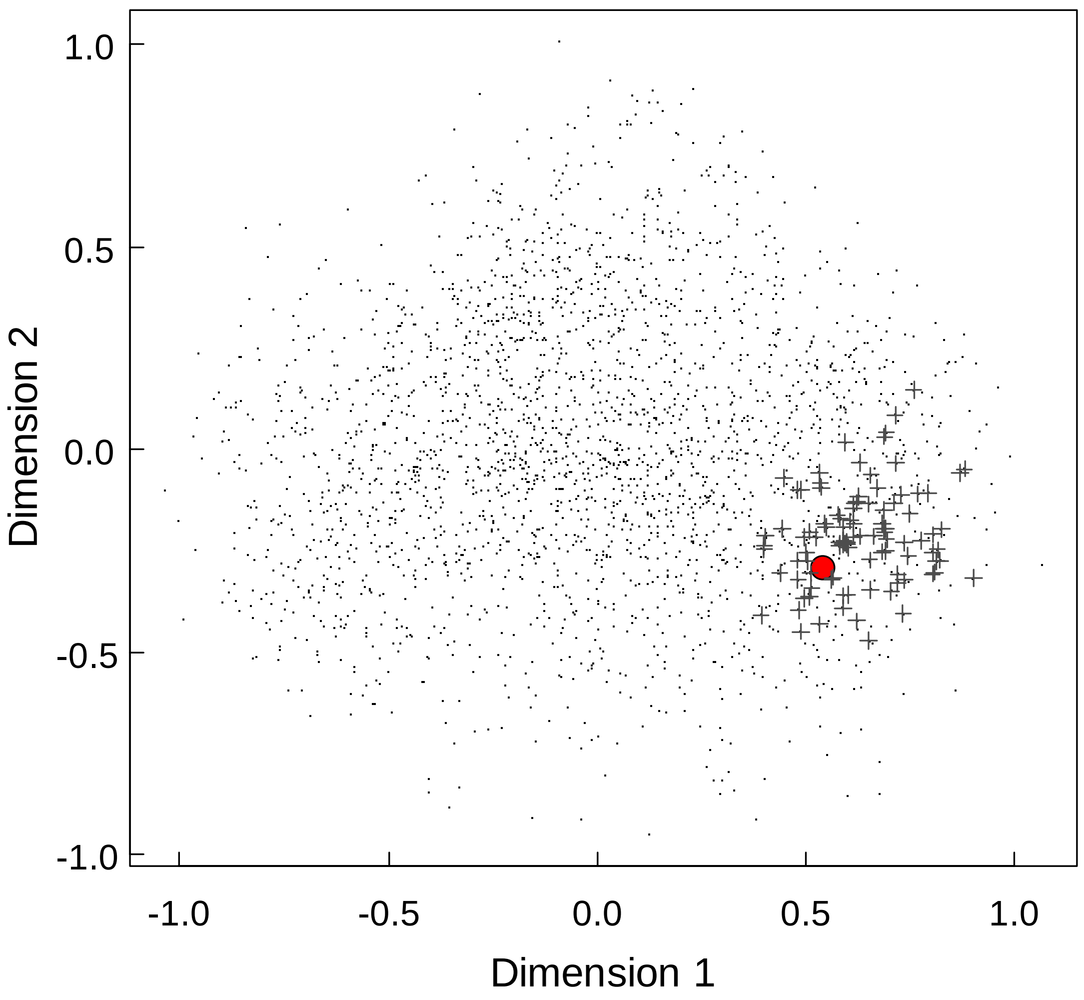

increasing topographic heterogeneity of landscape
increasing habitat diversity and increasing fragmentation


NMDS of 2551 forest relevés
1.0
0.5
0.0
-0.5
-1.0
Dimension 2
-1.0
-0.5
0.0
0.5
1.0
Dimension 1
Moist
Nutr
Soil.Reaction
Light
Temp

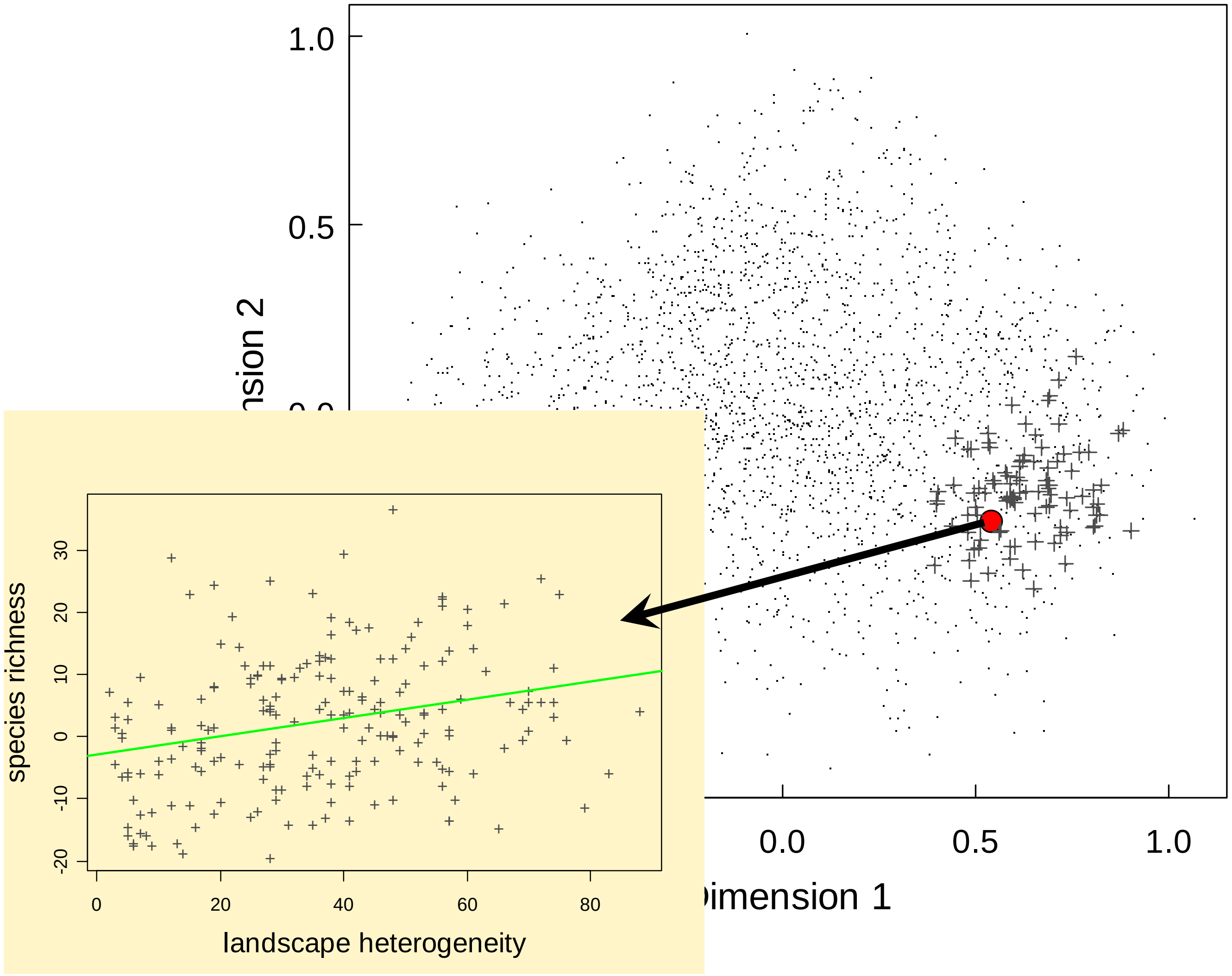

Species richness vs. heterogeneity
1.0
0.5
0.0
-0.5
-1.0
Dimension 2
-1.0
-0.5
0.0
0.5
1.0
Dimension 1


Species richness vs. heterogeneity
1.0
0.5
0.0
-0.5
-1.0
-1.0
-0.5
0.0
0.5
1.0
Dimension 2
Dimension 1

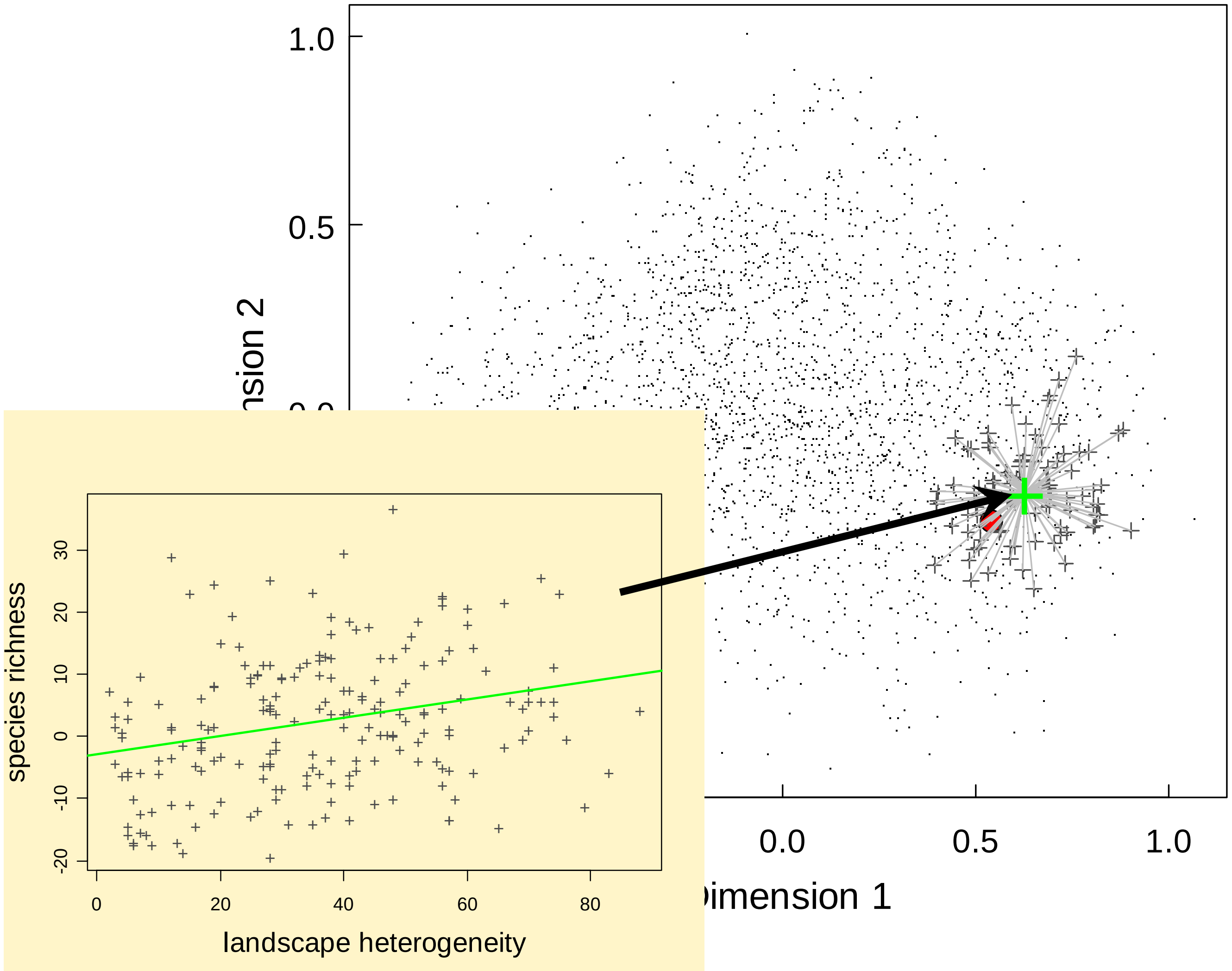
Species richness vs. heterogeneity

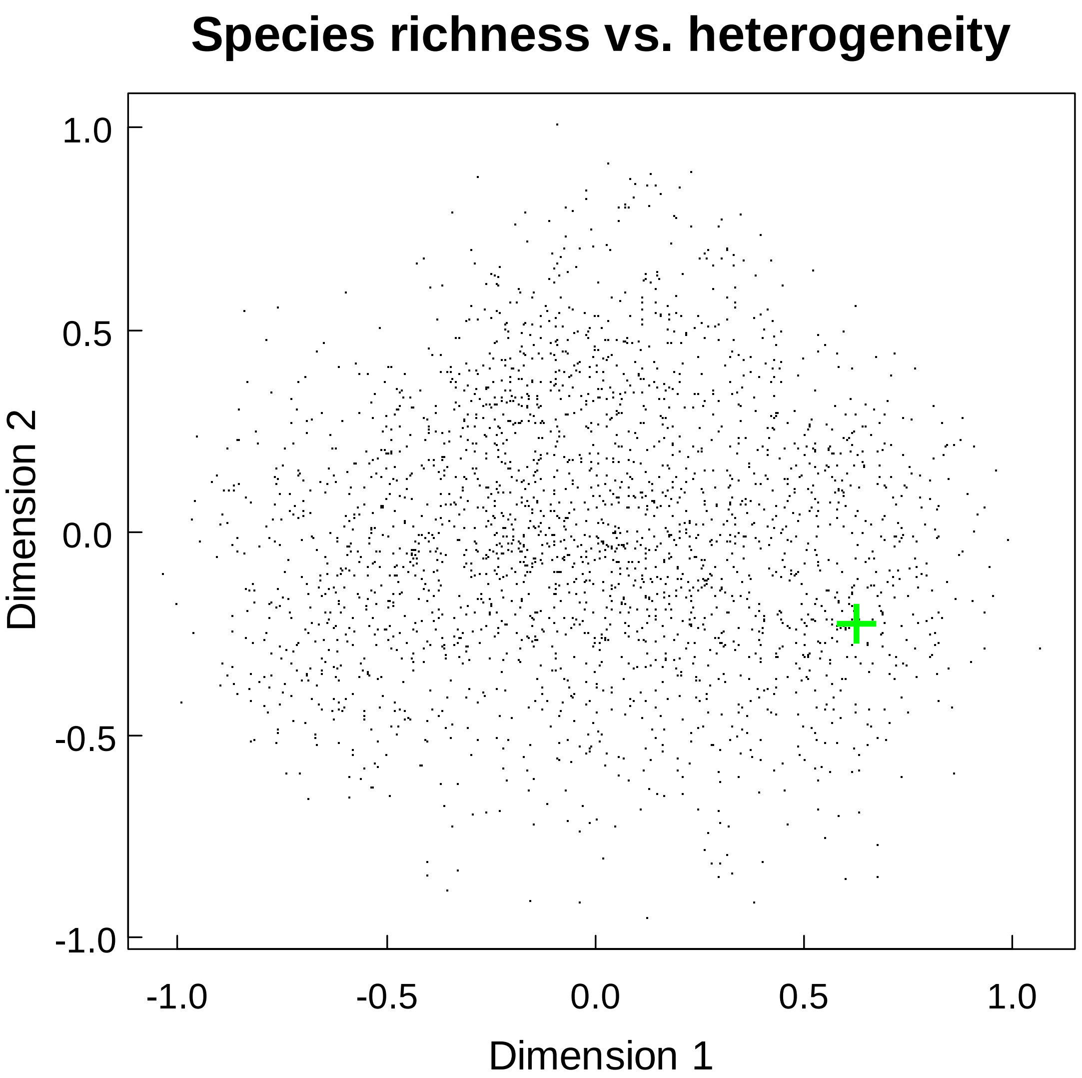


Species richness vs. heterogeneity

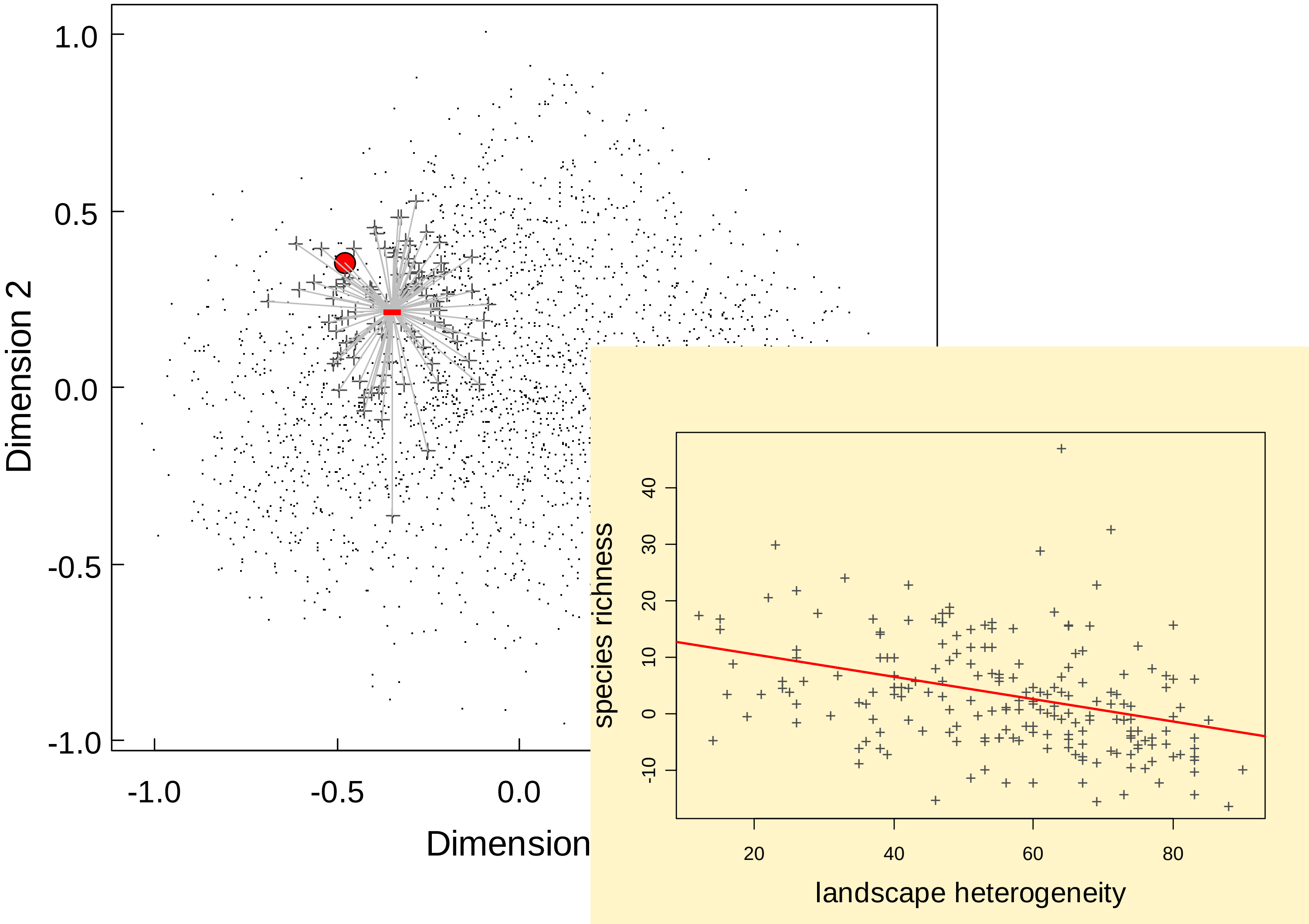


Species richness vs. heterogeneity

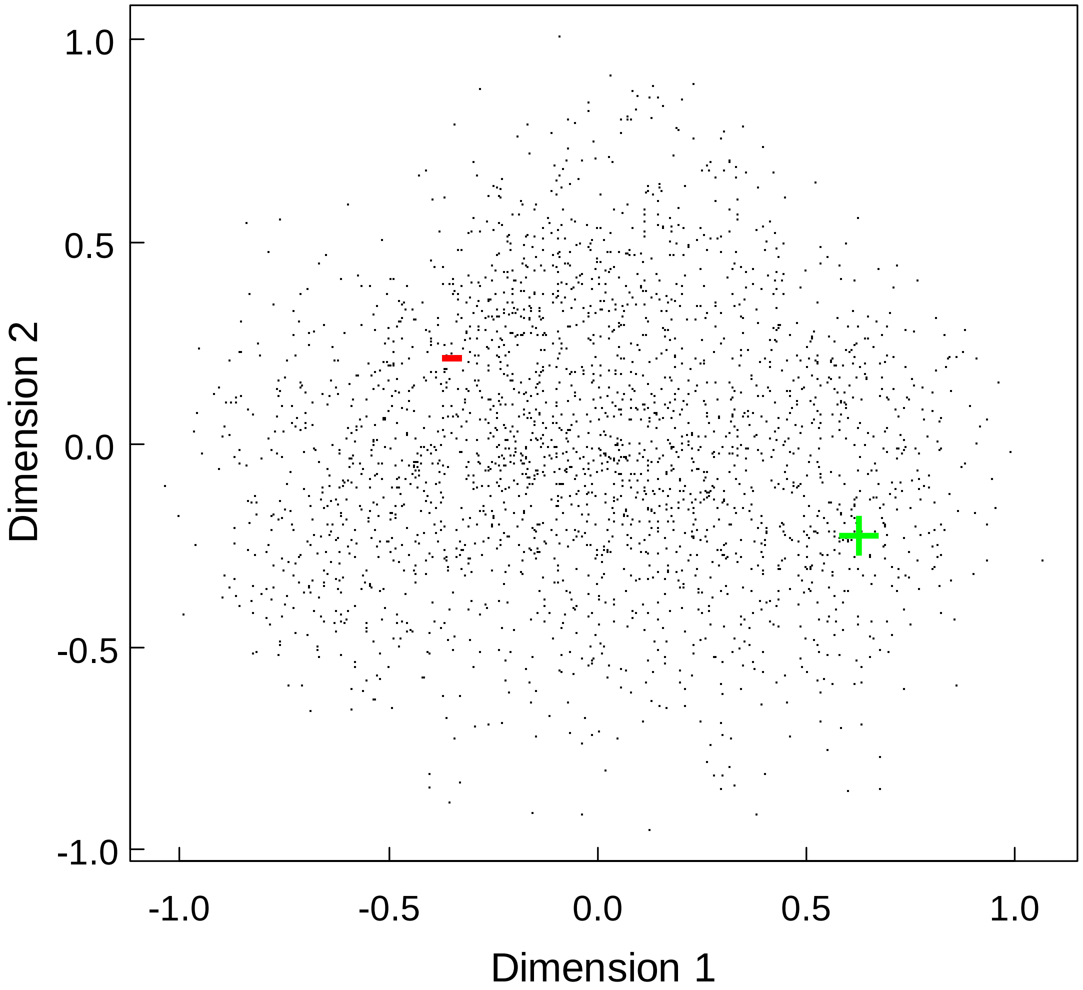


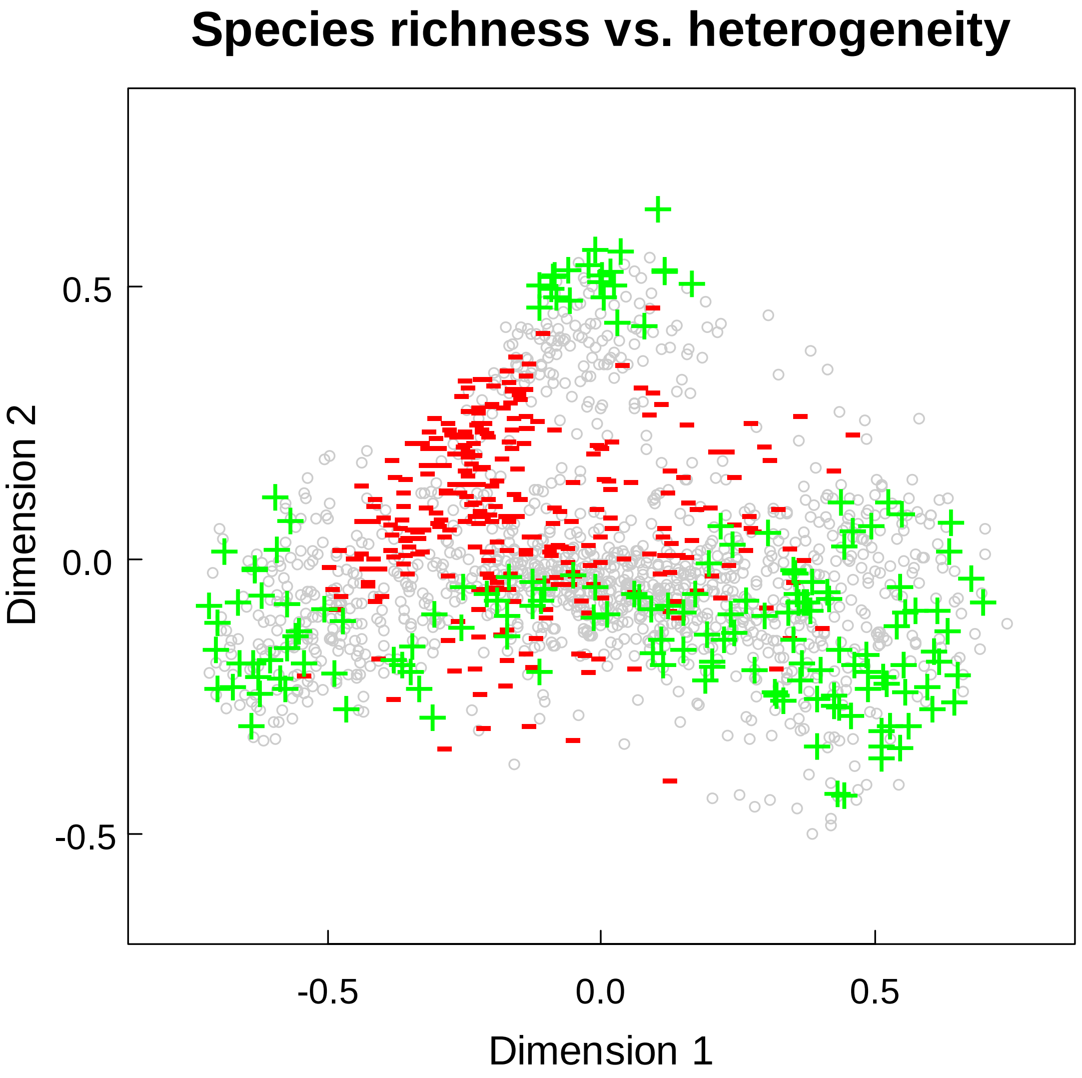

Species richness vs. heterogeneity
Dimension 2
Dimension 1
1.0
0.5
0.0
-0.5
-1.0
-1.0
-0.5
0.0
0.5
1.0

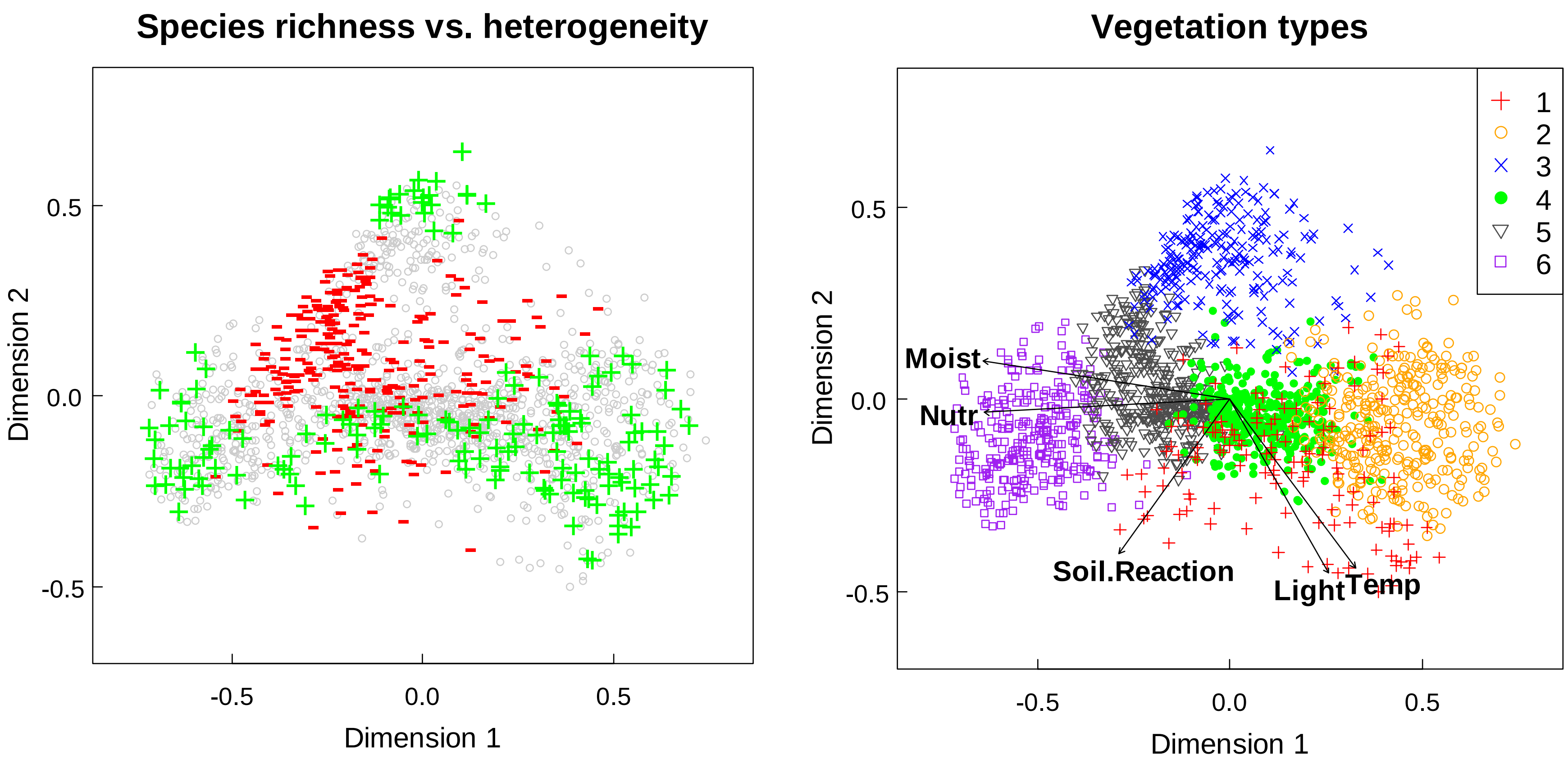
Species richness vs. heterogeneity

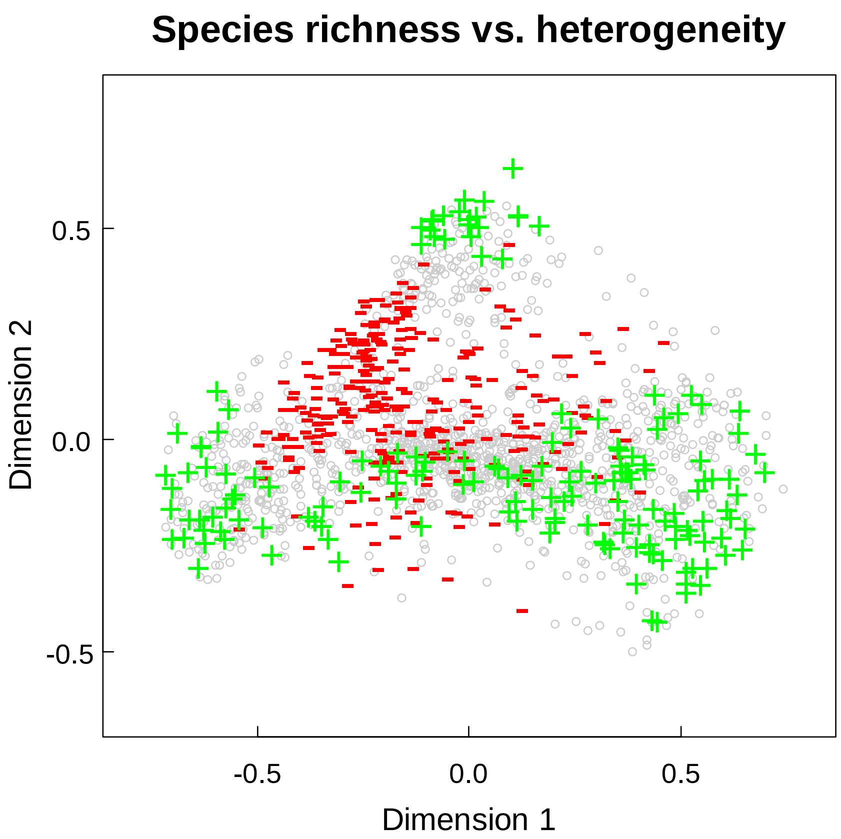


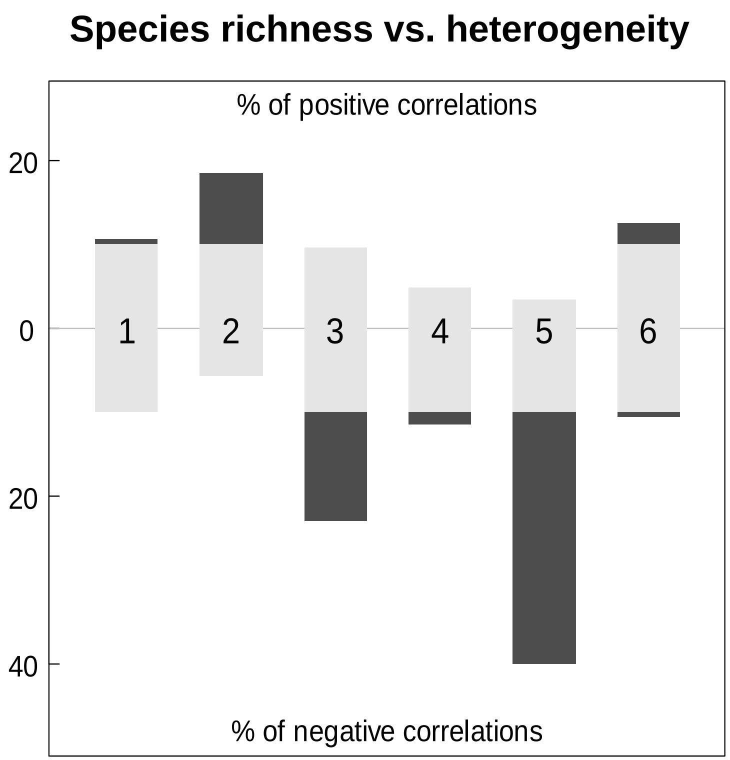
Species richness vs. heterogeneity



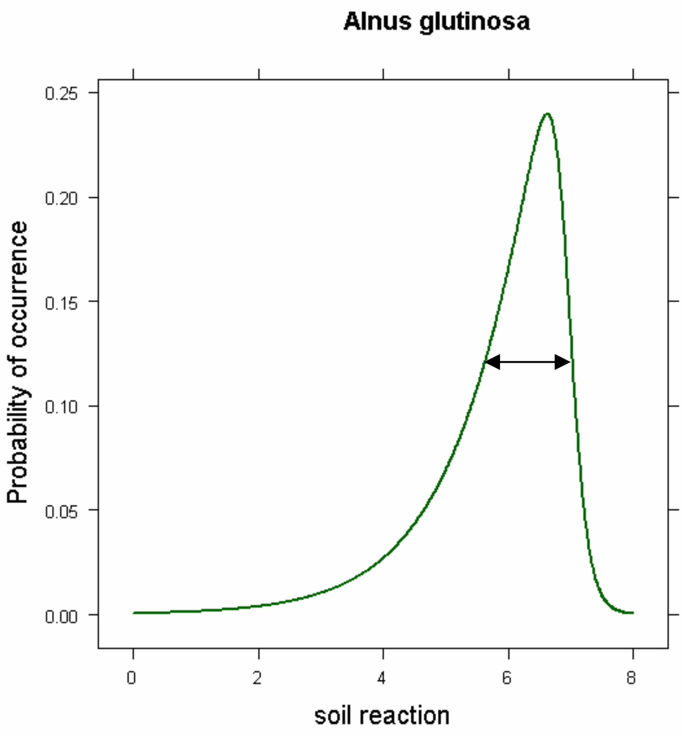

Species richness vs. heterogeneity
Dimension 2
0.5
0.0
-0.5
-0.5
0.0
0.5
Dimension 1


Species richness vs. heterogeneity
Dimension 2
Dimension 1
0.5
0.0
-0.5
-0.5
0.0
0.5
Vegetation types
1
2
3
4
5
6
Moist
Nutr
Soil.Reaction
Light
Temp
Dimension 2
Dimension 1
0.5
0.0
-0.5
-0.5
0.0
0.5


Species richness vs. heterogeneity
Dimension 2
Dimension 1
0.5
0.0
-0.5
-0.5
0.0
0.5


Species richness vs. heterogeneity
% of positive correlations
% of negative correlations
20
0
20
40
1
2
3
4
5
6

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

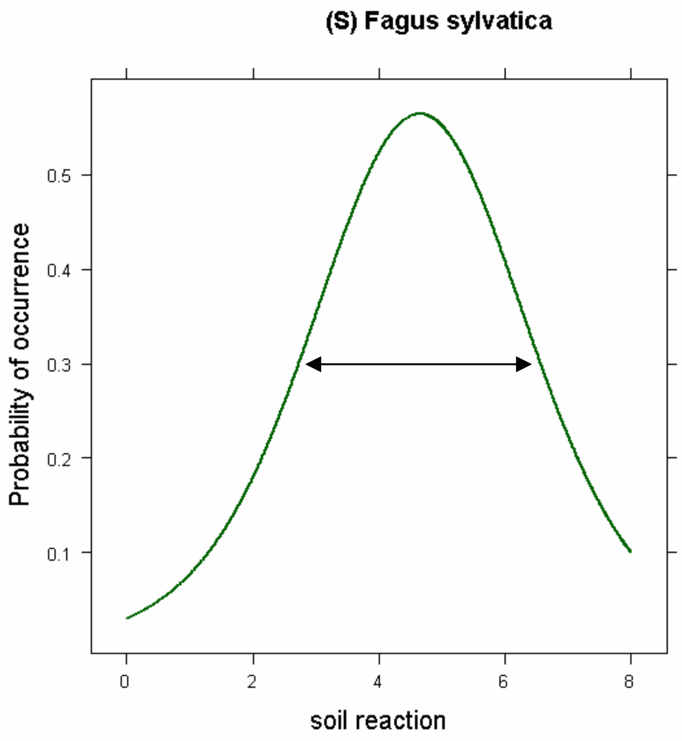


specialist

=

species with

narrow niche



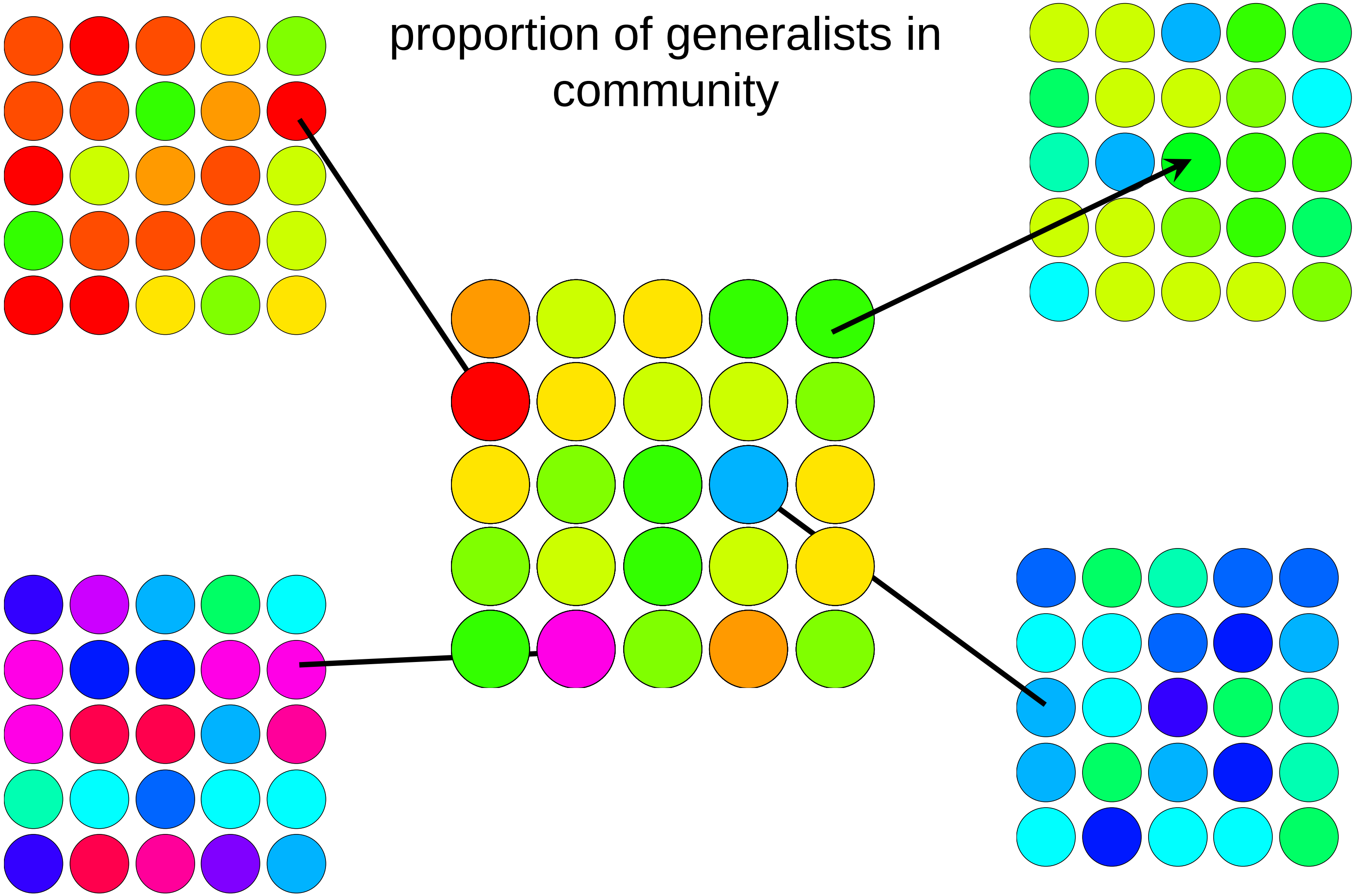
generalist

=

species with

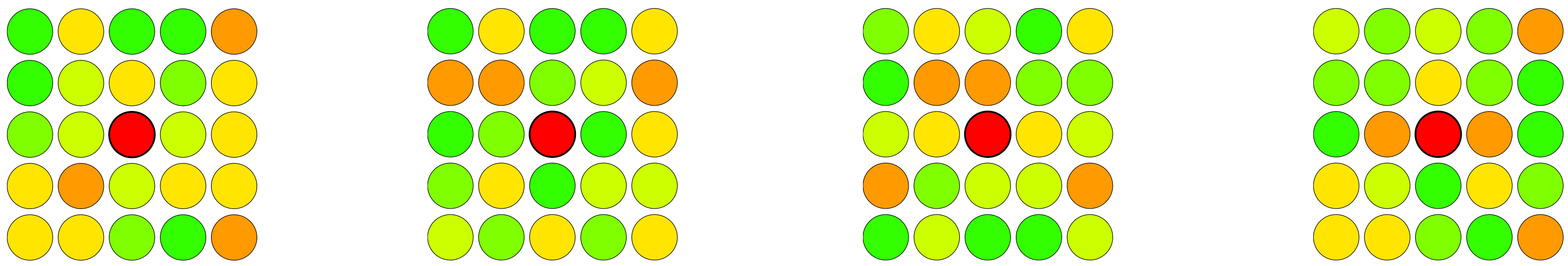
wide niche

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

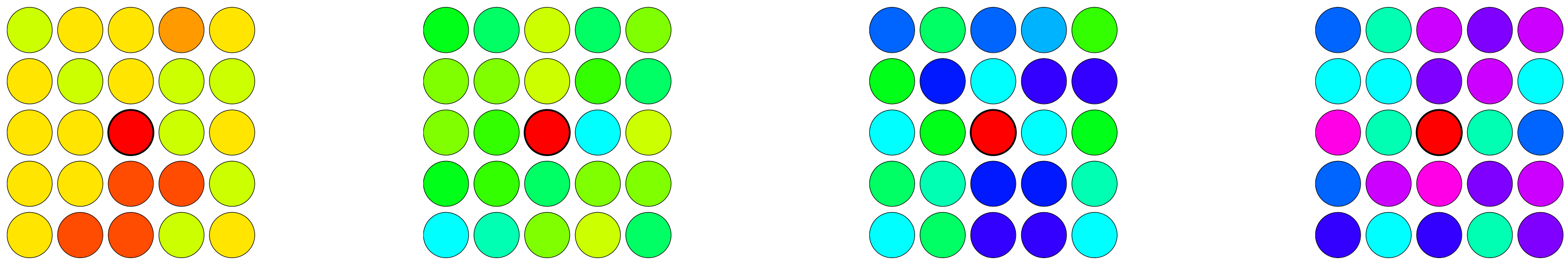


Steiner & Köhler (2003): Effects of landscape patterns on species richness – a modelling apporach. – *Agriculture, Ecosystems and Environment*, 98: 353-361.

Species habitat specialization based on the compositional differences among occupied habitats

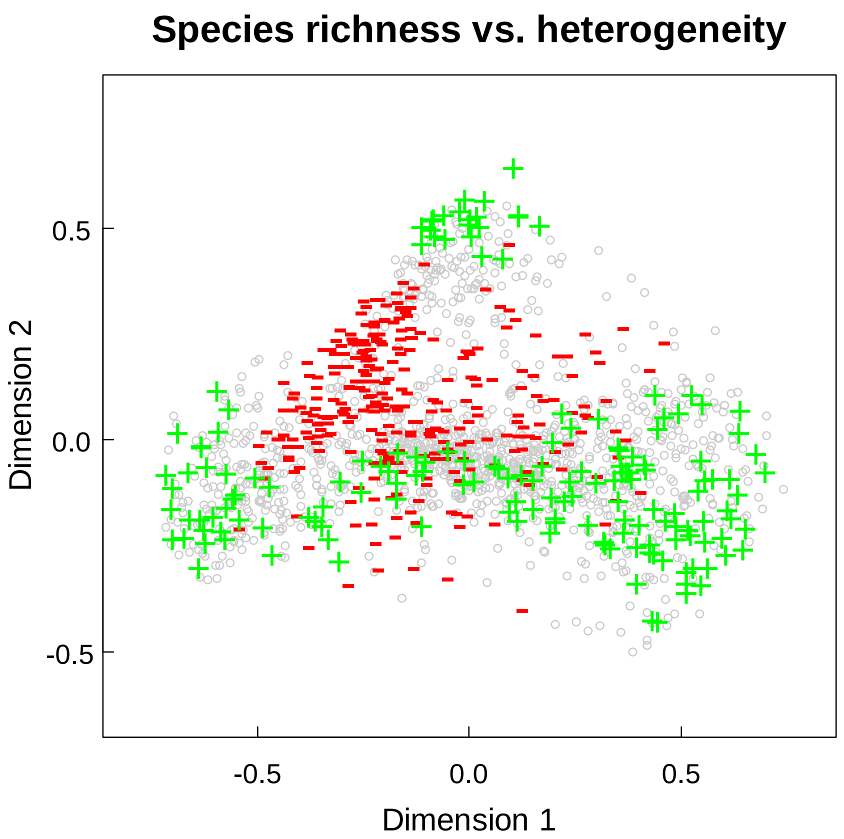


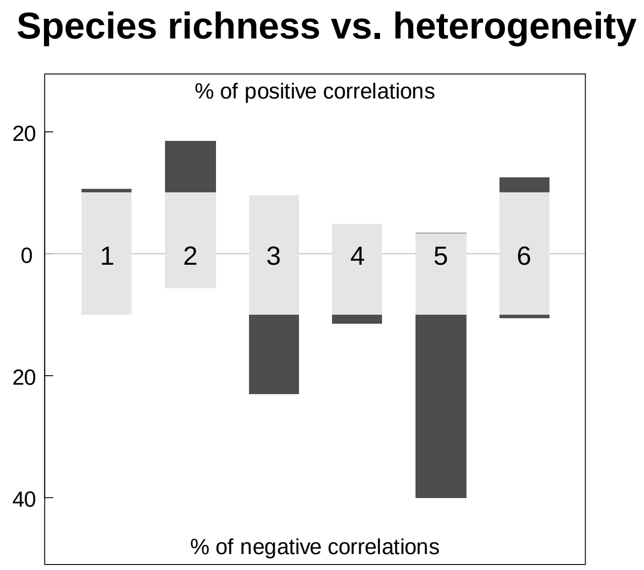
specialist – occurs in **similar** habitats with **similar** species composition

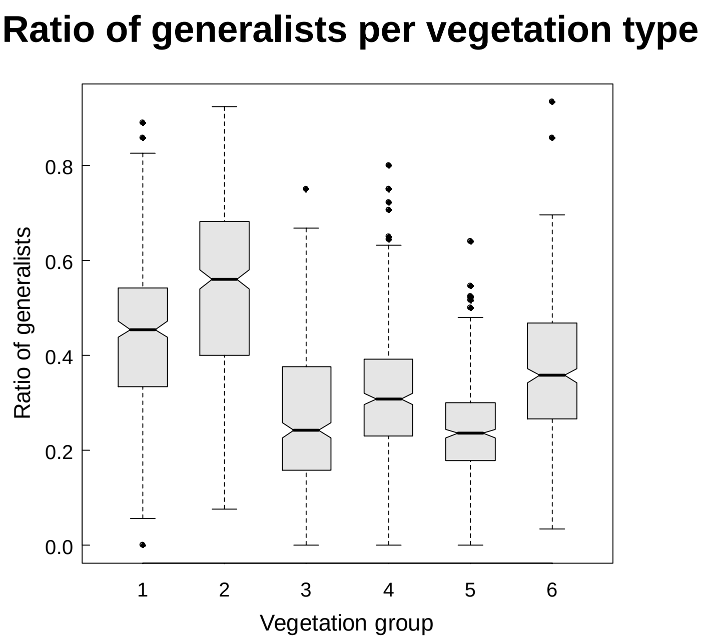


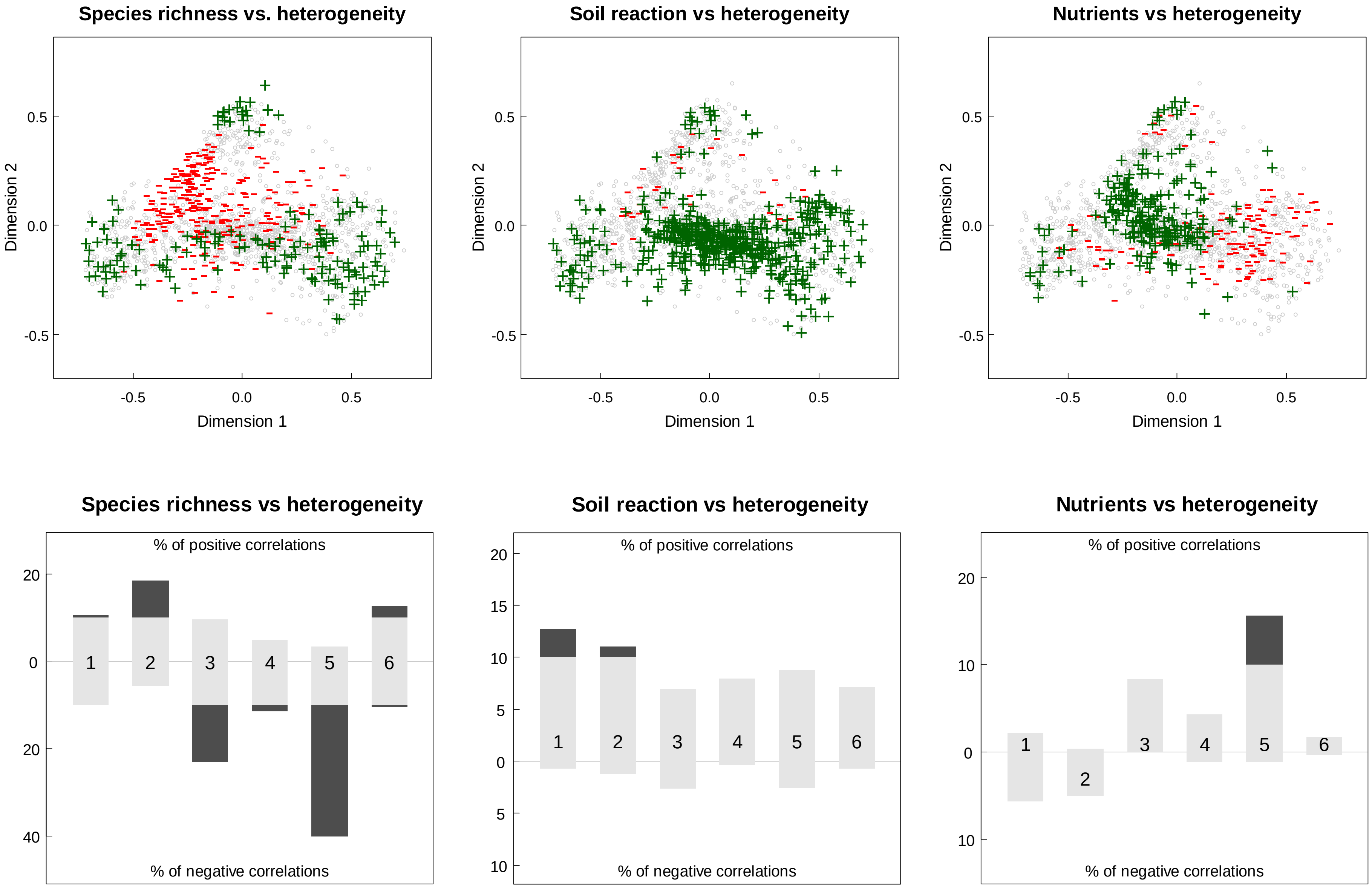
generalist – occurs in **various** habitats with **diverse** species composition

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.

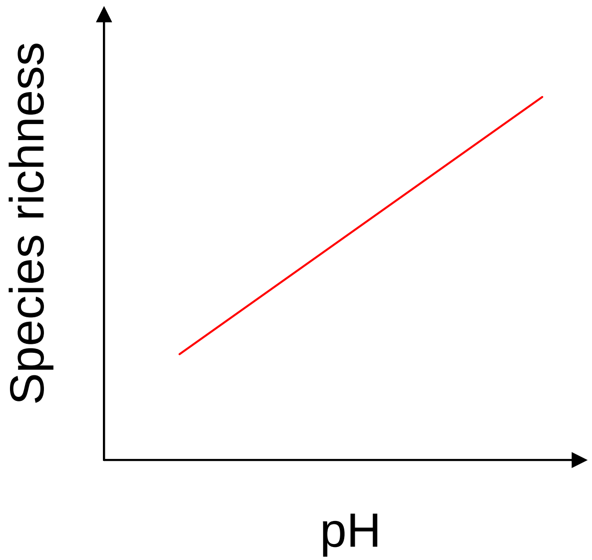

Species richness vs. heterogeneity
Dimension 1
Dimension 2
-0.5
0.0
0.5
0.5
0.0
-0.5

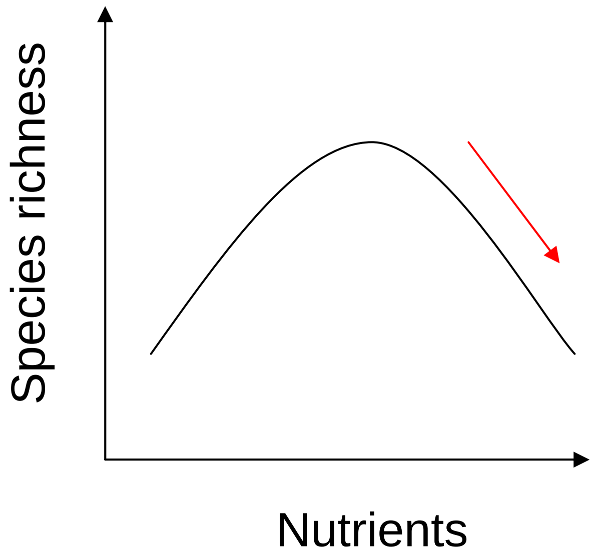

Species richness vs. heterogeneity
% of positive correlations
% of negative correlations
20
0
20
40
1
2
3
4
5
6


Ratio of generalists per vegetation type
Ratio of generalists
Vegetation group
0.0
0.2
0.4
0.6
0.8
1
2
3
4
5
6


Species richness vs. heterogeneity
Soil reaction vs heterogeneity
Nutrients vs heterogeneity
Dimension 1
Dimension 2
Species richness vs heterogeneity
Soil reaction vs heterogeneity
Nutrients vs heterogeneity
% of positive correlations
% of negative correlations
1
2
3
4
5
6

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





Conclusions

- toward the more heterogeneous landscape, species richness of some vegetation types increases (oak forests), decreases (beech forests, oak-hornbeam forests and ravine forests) or is ambiguous (alluvial forests);
- vegetation types with increased species richness in heterogeneous landscapes has at the same time higher proportion of habitat generalists – this may indicate the existence of spatial mass effect;
- the increase and decrease of species richness along the gradients of landscape heterogeneity might be also explained by the shift in microsite ecological conditions;
- the effect of the spatial mass effect and the shift in microsite ecological conditions doesn't need to be mutually exclusive.

Thank you for your attention!