Varying diversity patterns of vascular plants, bryophytes, and lichens at different spatial scales in central European landscapes

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Introduction

What we know

- Large-scale biodiversity patterns:
  - worldwide: downwards to 10,000 km²
  - central Europe & UK: downwards to approx. 30 km² (1 km²)
- Vertebrates and vascular plants

What we don‘t really know

- **Small-scale biodiversity patterns**, i.e. 1 mm² - 10,000 m²
  - What is the average species density on 100 m² (1 m², 0.01 m²)?
  - What is the most frequent plant species on 100 m² (1 m², 0.01 m²)?
- General description and understanding of the **scale dependence** of (nearly) all biodiversity parameters
- Biodiversity patterns of **non-vascular plants** (bryophytes, lichens, macro-algae)

Existing small-scale sampling schemes

Phytosociological relevés/databases

Ecological monitoring programmes, e.g.

- Ecological Area Sampling (EAS) in Germany
- Biodiversity Monitoring (BDM) in Switzerland
- Forest monitoring (Level II) in Europe

Common problems

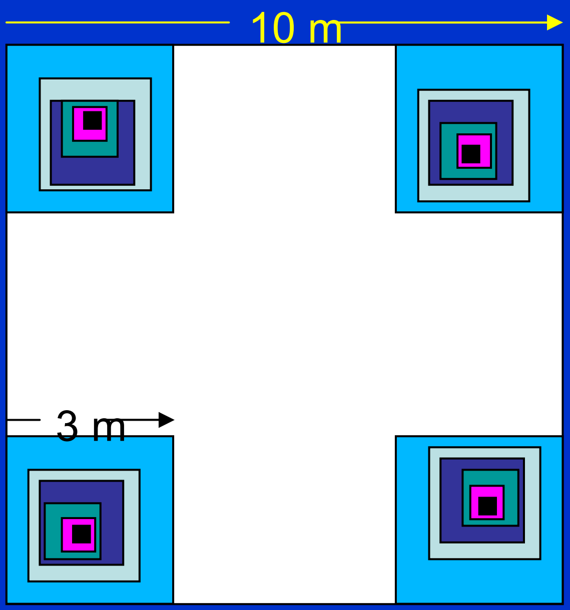
- No uniform plot sizes
- Only one spatial scale analysed
- Bryophytes and lichens not recorded (or sampled with a deviating approach)
- Other methodological problems
- Sampling within predefined vegetation units disables integration of results on landscape level

Dengler, J. (2008, in press): Pitfalls in small-scale species-area sampling and analysis. – Folia Geobot. 43: ca. 16 pp.

Methods

Plot series

- 7 spatial scales, near-equally spread on the log (*A*) scale: 0.0001 m²; 0.0009 m²; 0.01 m²; 0.09 m²; 1 m²; 9 m²; 100 m²
- Smaller plots replicated 4x in a nested manner within the 100-m² plots



- Complete species lists for all scales
- Cover and environmental data for 9 m²
- All vascular plants, bryophytes, and lichens (including non-terricolous plants and cultivated plants)
- Recording as shoot presence (not rooted presence)

Dengler, J. (subm.): A flexible, multi-scale approach for standardised assessment of plant species richness patterns . – Ecol. Indic.

Arrangement of 100-m² plots

- Chosen irrespective of land use and within-plot heterogeneity within the studied landscape sector
- Random coordinates were generated and localized in the field with a GPS

The two study areas in N Germany

- **Lüneburg** (diploma thesis Marc-André Allers):
  - 50 nested plot series within 130 km² (Topographic map sheet 2728)
  - Urban landscape in Lower Saxony
  - 35% forest – 10% grassland – 30% arable land – 25% settlement

- **Brodowin** (student course):
  - 16 nested plot series withín 6 km²
  - Rural landscape in Brandenburg
  - 50% forest – 25% grassland – 20% arable land – 5% settlement

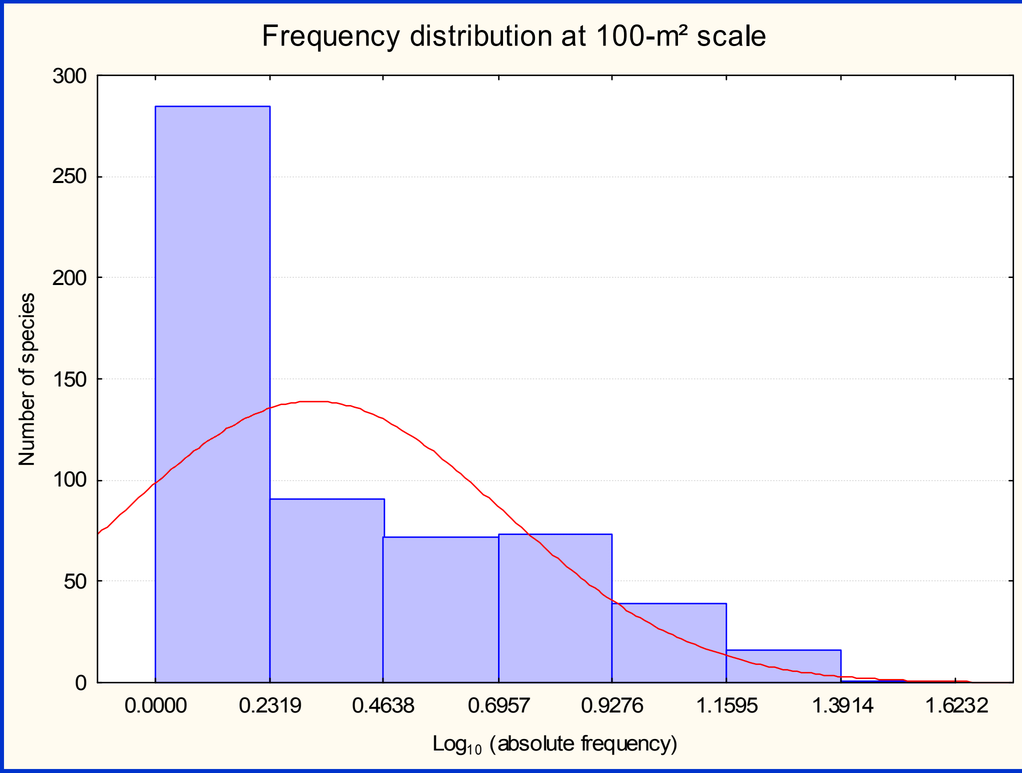
Dengler, J. (subm.): A flexible, multi-scale approach for standardised assessment of plant species richness patterns . – Ecol. Indic.

Results

Frequency of species

- **Total richness recorded in Lüneburg** (50x 100-m² plots): 468 vascular plants – 48 bryophytes – 61 lichens
- **Species-frequency distribution**:

  ► far from the postulated log-normal distribution for all spatial scales



- **Most frequent species** (100-m² plots):

Lower Saxony	%	Brandenburg	%
Brachythecium rutabulum	84	Brachythecium rutabulum	81
Lolium perenne	48	Hypnum cupressiforme var. cupr.	63
Holcus lanatus	46	Elymus repens	56
Agrostis capillaris	44	Stellaria media	56
Hypnum cupressiforme var. cupr.	44	Taraxacum spec.	50
Quercus robur	44	Impatiens parviflora	44
Elymus repens	42	Bryum spec.	44
Festuca rubra agg.	42	Fagus sylvatica	44
Taraxacum spec.	40	Lepraria incana	44
Lepraria incana	40	Lolium perenne	44
Stellaria media	38	Lophocolea heterophylla	44
Scleropodium purum	34	Poa trivialis ssp. trivialis	44
Dactylis glomerata ssp. glomerata	32	Urtica dioica	44
Rubus spec.	30	Cerastium holosteoides	38
Sorbus aucuparia	30	Chenopodium album	38

- *Brychythecium rutabulum* was the most frequent species for six scales; only at 1 cm², *Pinus sylvestris* and *Fagus sylvatica* (10%) were slightly more frequent than this moss (8%)

Species density at different spatial scales

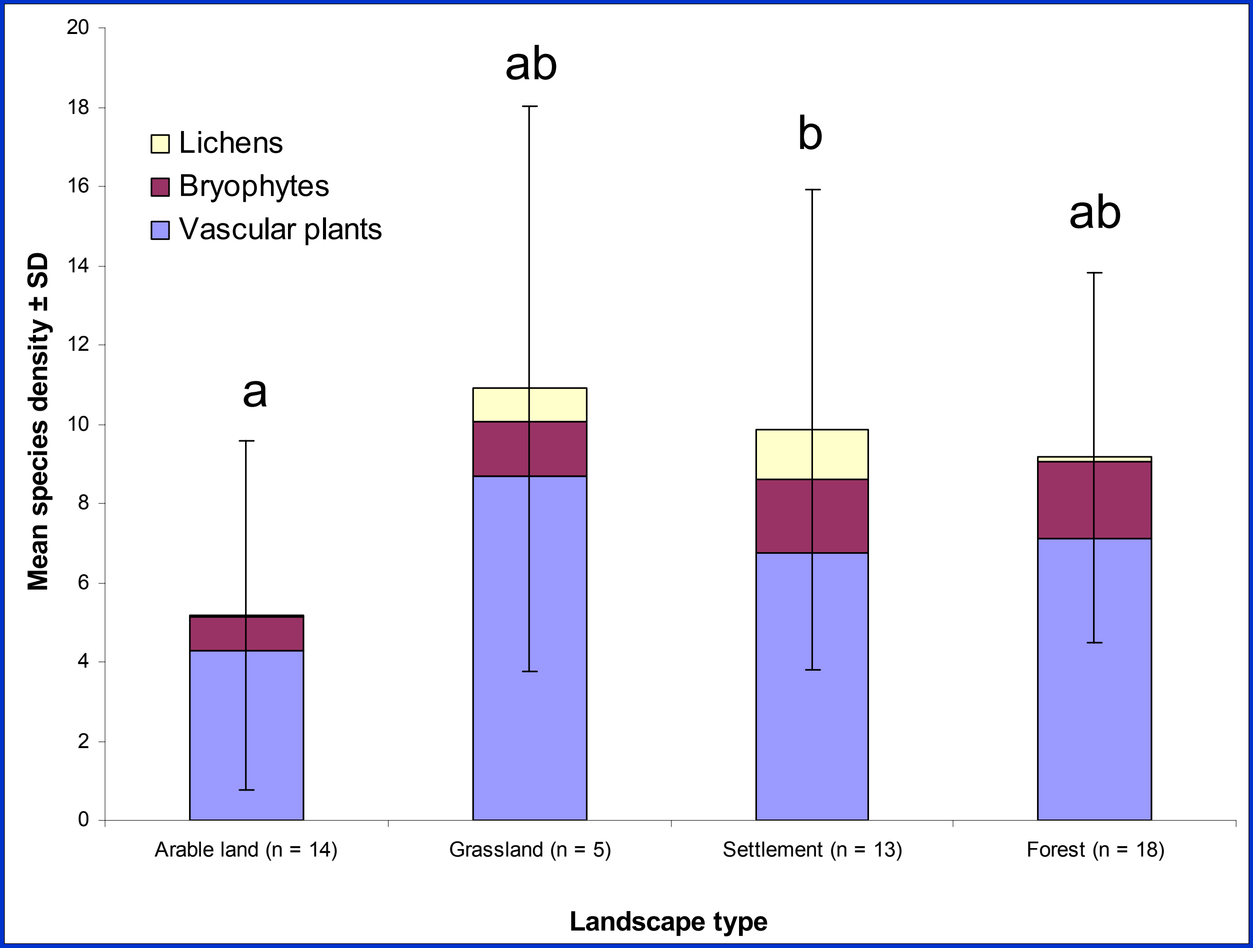
- **Total species density**

Area [m²]	Mean ± SD		Difference	Absolute		Coefficient of variation	
	Lüneburg	Brodowin		Minimum	Maximum	Lüneburg	Brodowin
0.0001	**1.6** ± 1.2	NA	NA	0	5	75%	NA
0.0009	**2.4** ± 1.7	**2.7** ± 1.8	13%	0	9	71%	67%
0.01	**3.5** ± 2.4	**4.2** ± 2.5	20%	0	13	69%	60%
0.09	**5.1** ± 3.4	**6.2** ± 3.3	22%	0	15	67%	53%
1	**8.5** ± 5.6	**11.0** ± 5.9	29%	0	28	66%	54%
9	**15.2** ± 9.8	**18.1** ± 8.6	19%	0	55	64%	48%
100	**38.7** ± 25.5	**42.9** ± 22.2	11%	2	137	66%	52%

► Higher species densities in Brodowin at all scales presumably can be attributed to higher regional species pool

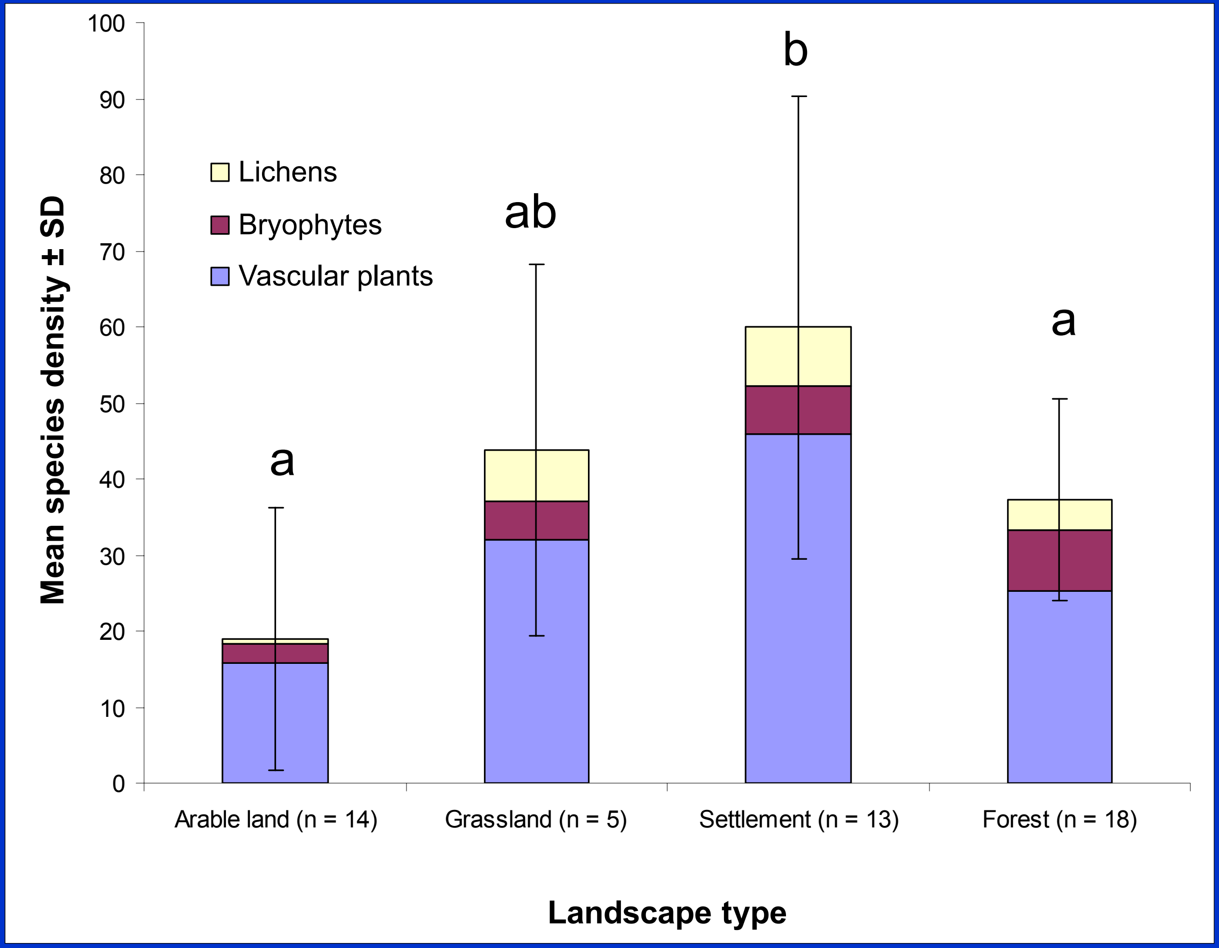
► Lower CV of species densities in Brodowin at all scales presumably can be attributed to the smaller size of this landscape sector

- **Species densities in different landscape types**
  - ► At 1-m² scale



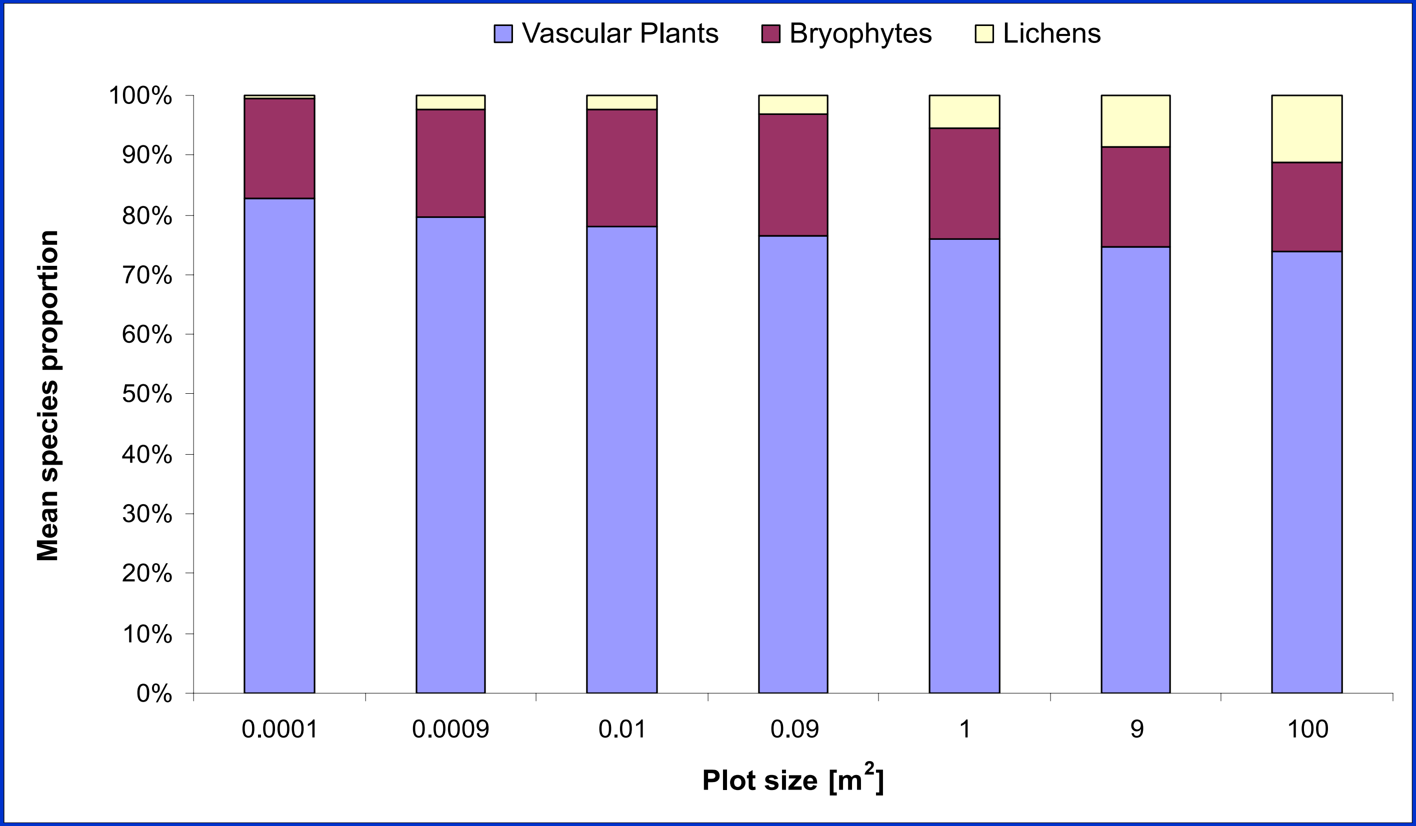
▪ Species densities in different landscape types

► At 100-m² scale

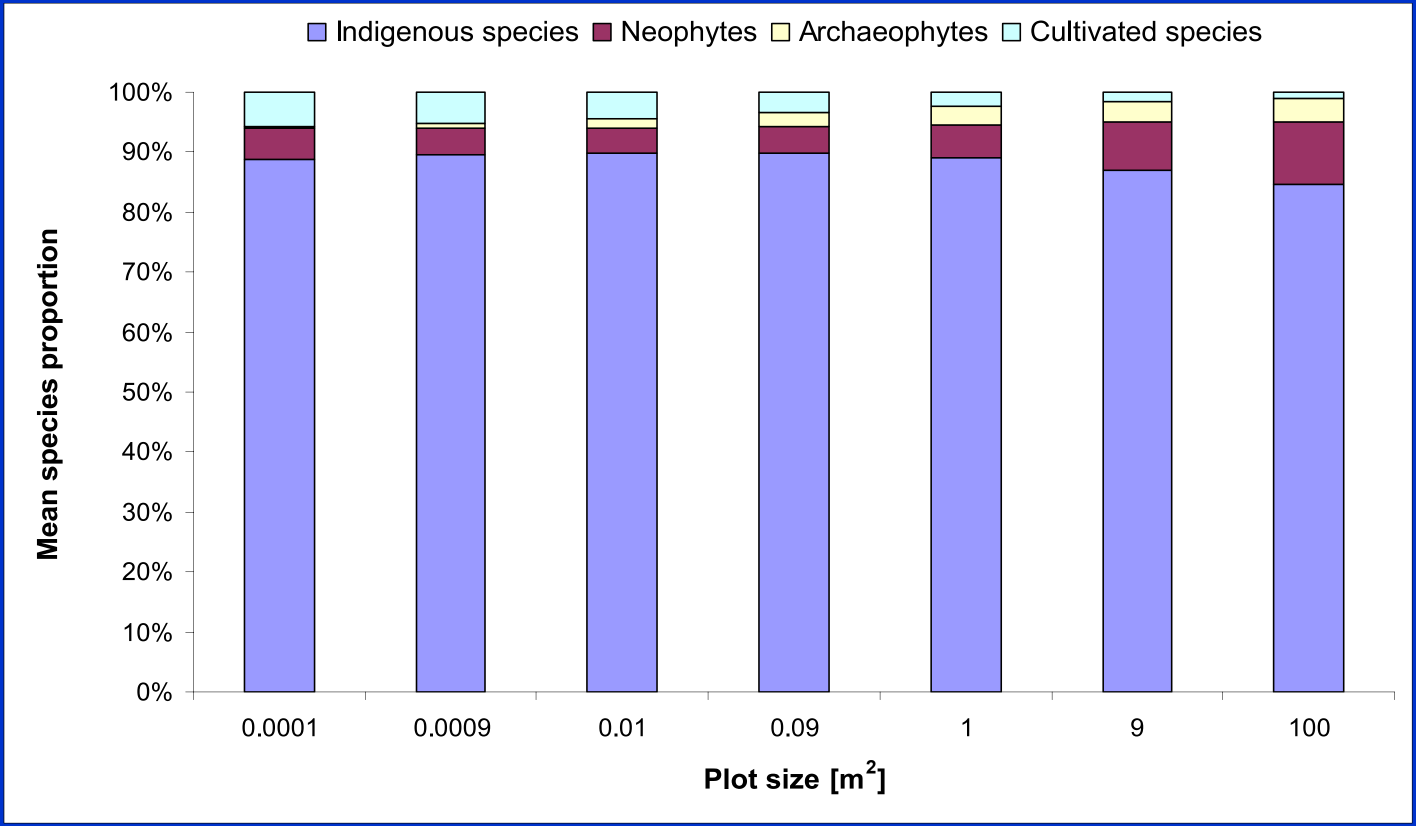


Proportions of species groups dependent on scale

- ► Major taxonomic groups



- **Proportions of species groups dependent on scale**
  - ► Floristic status



Species-area relationships (SARs)

- **Best fitting model**
  - The **power function** $S = c\,A^z$ on average was the best fitting function for the 50 SARs
  - Logarithmic (“exponential”) and saturation functions in most cases only poorly fitted the data
- **Variability of *z***

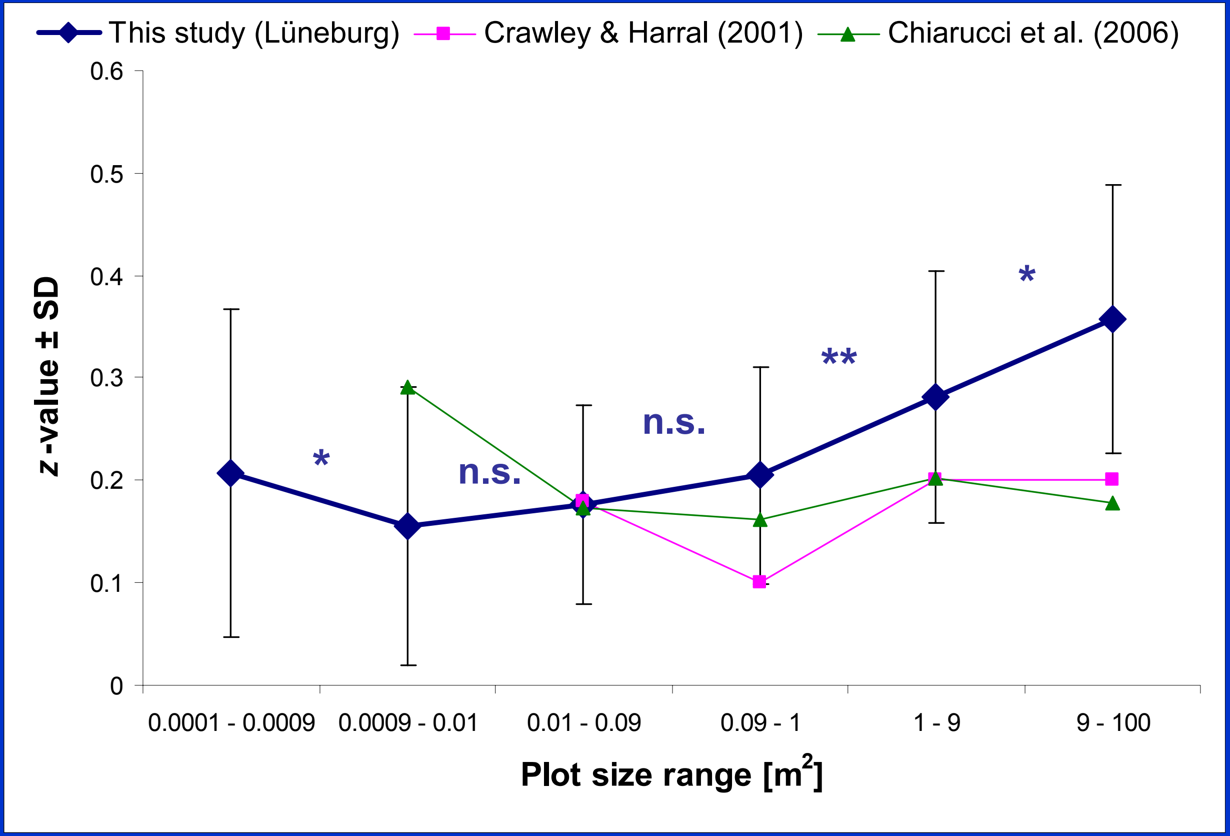
All taxa	Vascular plants	Bryophytes	Lichens
0.327	0.322	0.271	0.481

Indigeneous species	Neophytes	Archaeophytes	Cultivated species
0.315	0.472	0.428	0.091

Arable land	Settlement	Grassland	Forests
0.276	0.404	0.252	0.288

  - High *z*-value = high spatial turnover

Scale dependency of *z*



Chiarucci, A., Viciani, D., Winter, C., Diekmann, M. (2006): Effects of productivity on species-area curves in herbaceous vegetation: evidence from experimental and observational data. – Oikos 115: 475–483.

Crawley, M. J., Harral, J. E. (2001): Scale Dependence in Plant Biodiversity. – Science 291: 864–868, Washington, DC.

Conclusions

- Most of the analysed biodiversity parameters and relationships are significantly influenced by spatial scale
- Bryophytes and lichens usually contribute considerably to total plant diversity, but their biodiversity parameters “behave” differently from those of vascular plants
- Thus, in studies on plant diversity patterns several spatial scales and also non-vascular plants should be included
- The proposed biodiversity sampling scheme provides a wide range of standardised biodiversity indicators
- This approach is particularly suitable for comparing biodiversity patterns and for monitoring biodiversity change at landscape scale