Comparative analysis of species-area relationships in European dry grasslands – across regions, taxa, and scales

Jürgen DENGLER (Univ. Lüneburg), Steffen BOCH (Univ. Potsdam), Christian DOLNIK (Univ. Kiel), Michael JESCHKE (TU München, Freising), Kathrin KIEHL (TU München, Freising) & Swantje LÖBEL (Univ. Uppsala)

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1. Material and Methods
   - Data sources
   - Curve fitting
2. Suitability of different function types
3. Dependence of SAR parameters on:
   - vegetation type
   - geographic region
   - taxonomic group
   - spatial scale
4. Conclusions and outlook

Data selection

- ► Nested-plot data covering a wide range of plot sizes
- ► Preferably including vascular plants, bryophytes, and lichens

Sources

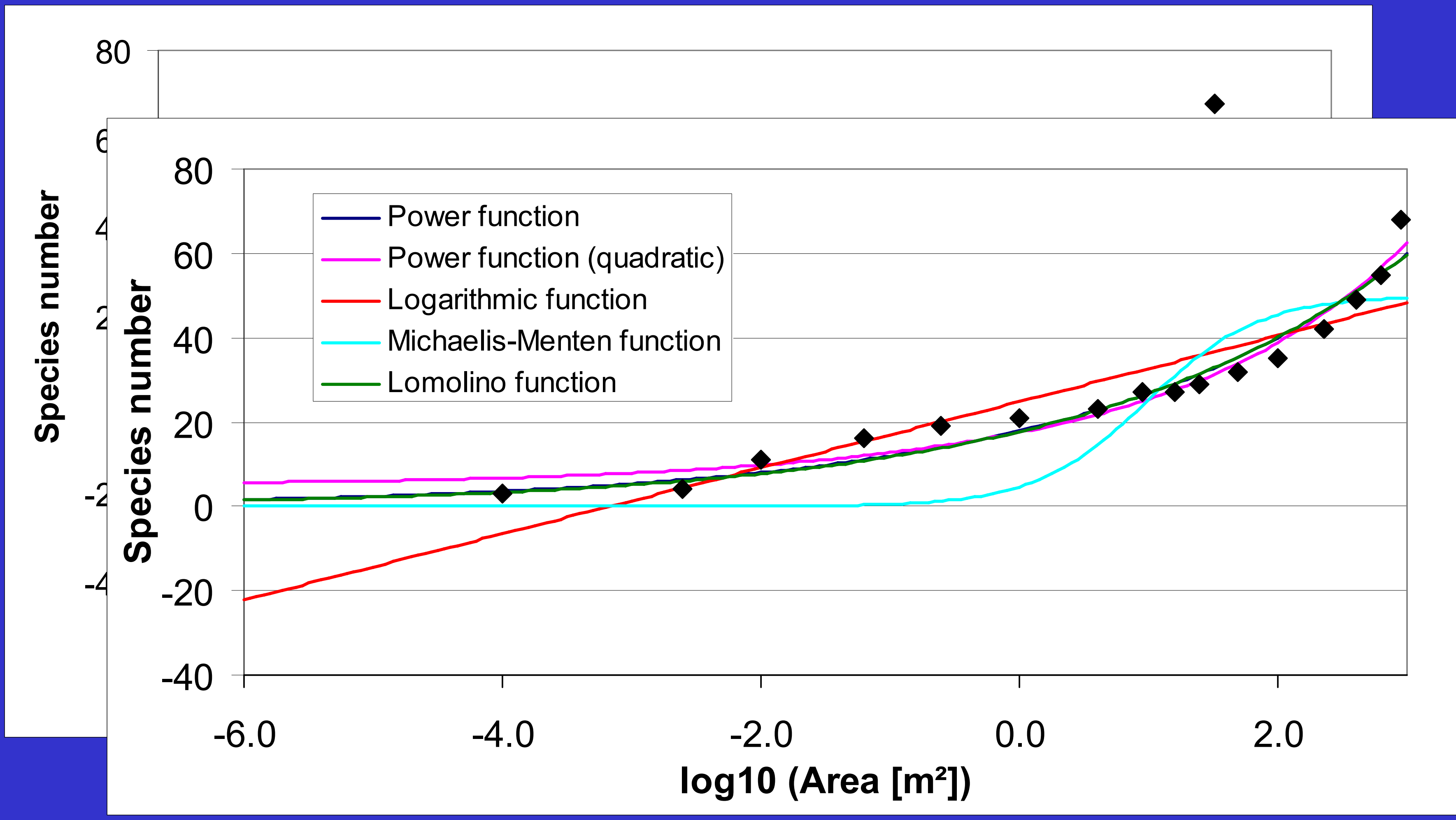
Study region	*Latitude*	*Plot size range*	*n*	*Source*
Switzerland	47° N	0.25-49 m²	10	Kammer (1997)
Bavaria and Switzerland	48° N	0.01-100 m²	52	PhD thesis Jeschke (2007)
United Kingdom	53° N	0.01-1 m²	3	Archibald (1949)
NW Germany	53° N	0.0001-100 m²	4	Diploma thesis Allers (2007)
NE Germany	53° N	0.000001-100 m²	10	Dengler et al. (2004)
Kaliningrad (Russia)	56° N	0.0001-900 m²	17	Dolnik (2003)
Kaliningrad (Russia)	56° N	0.0001-16 m²	13	Dolnik (2006)
Öland (Sweden)	56° N	0.0001-9 m²	31	Diploma thesis Löbel (2002)
Saaremaa (Estonia)	59° N	0.0001-100 m²	16	Diploma thesis Boch (2005)

Function types tested

1. Power function: $S = c\,A^z$
2. Quadratic power function: $S = 10^{(x + y \log_{10}(A) + z (\log_{10}(A))^2)}$
3. Logarithmic function: $S = x + y \log_{10}(A)$
4. Convex saturation function: Michaelis-Menten function
   $S = x A / (y + A)$
5. Sigmoid saturation function: Lomolino function
   $S = x / (1 + (y^{\log_{10}(z / A)}))$

compare:
Tjørve, E. (2003): Shapes and functions of species-area curves: a review of possible models. – J. Biogeogr. 30: 827–835.

Function types



Curve fitting

► Non-linear regression

► Each function type fitted both for S and log (S)

e.g. power function: $\mathbf{S = c\,A^{z}} \Leftrightarrow \mathbf{\log(S) = \log(c) + z \log(A)}$

Assessment of fitting quality

1. Akaike's Information Criterion for small n (AICc) for S
2. AICc for log S
3. Log Error of Extrapolation (LEE):
   - Model with data points except for those ≥ $A_{max}/10$
   - Difference of $S_{pred}(A_{max}) - S_{obs}(A_{max})$ on log-scale

Suitability of different function types

► 50 series of nested plots selected from the whole data set

	ΔAICc (S)		ΔAICc (log *S*)		LEE		
	Mean	# of best fits	Mean	# of best fits	Mean	Mean Rank	# of best fits
Power (*S*)	4.0	28	13.0	-	**0.04**	3.4	11
Power (log *S*)	14.9	-	5.5	19	**0.11**	5.0	8
Power, quadr. (*S*)	3.5	13	10.3	-	**-0.07**	3.9	5
Power, quadr. (log *S*)	10.9	-	2.4	22	**-0.07**	3.9	14
Logarithm (S)	25.3	3	n. d.	-	**-0.17**	5.6	3
Logarithm (log *S*)	34.0	-	21.4	3	**-0.28**	7.7	2
Michaelis-Menten (*S*)	29.0	1	56.9	-	**-0.25**	7.6	0
Michaelis-Menten (lg S)	40.4	-	29.7	1	**-0.45**	9.5	1
Lomolino function (*S*)	5.2	5	13.2	-	**-0.06**	3.9	5
Lomolino function (lg *S*)	13.1	0	4.9	5	**-0.08**	4.6	1

Function types

► Power and quadratic power generally performed best

► Other functions normally only performed best when the smaller plot sizes were not replicated (17 curves out of 50 in total):

	best performance for non-power function	proportion of these with non-replicated smaller plots
AICc (S)	18%	89%
AICc (log S)	18%	89%
LEE	24%	75%

► Non-power functions thus can be attributed to stochasticity due to non-averaged values rather than to ‘real’ differences in the curve shapes

► Best solution: **‘normal‘ power function with variable increment (*z*)**
- generally suitable
- quadratic power function results in increments < 0 and > 1 for very low or high values of *A*

► Power-law fitted for *S* vs. power-law fitted for log *S*

Parameter	***S***	**log *S***	
c	27.93	28.92	$p = 0.0077$
z	0.2043	0.2331	$p = 0.0004$

► ***All following analyses with normal power law fitted for S***

Parameters of power-law species-area relationships

► 143 curves for the range 0.01 – 16 m² (at least 0.01 – 9 m²)

► Total species number (vascular plants, bryophytes, lichens)

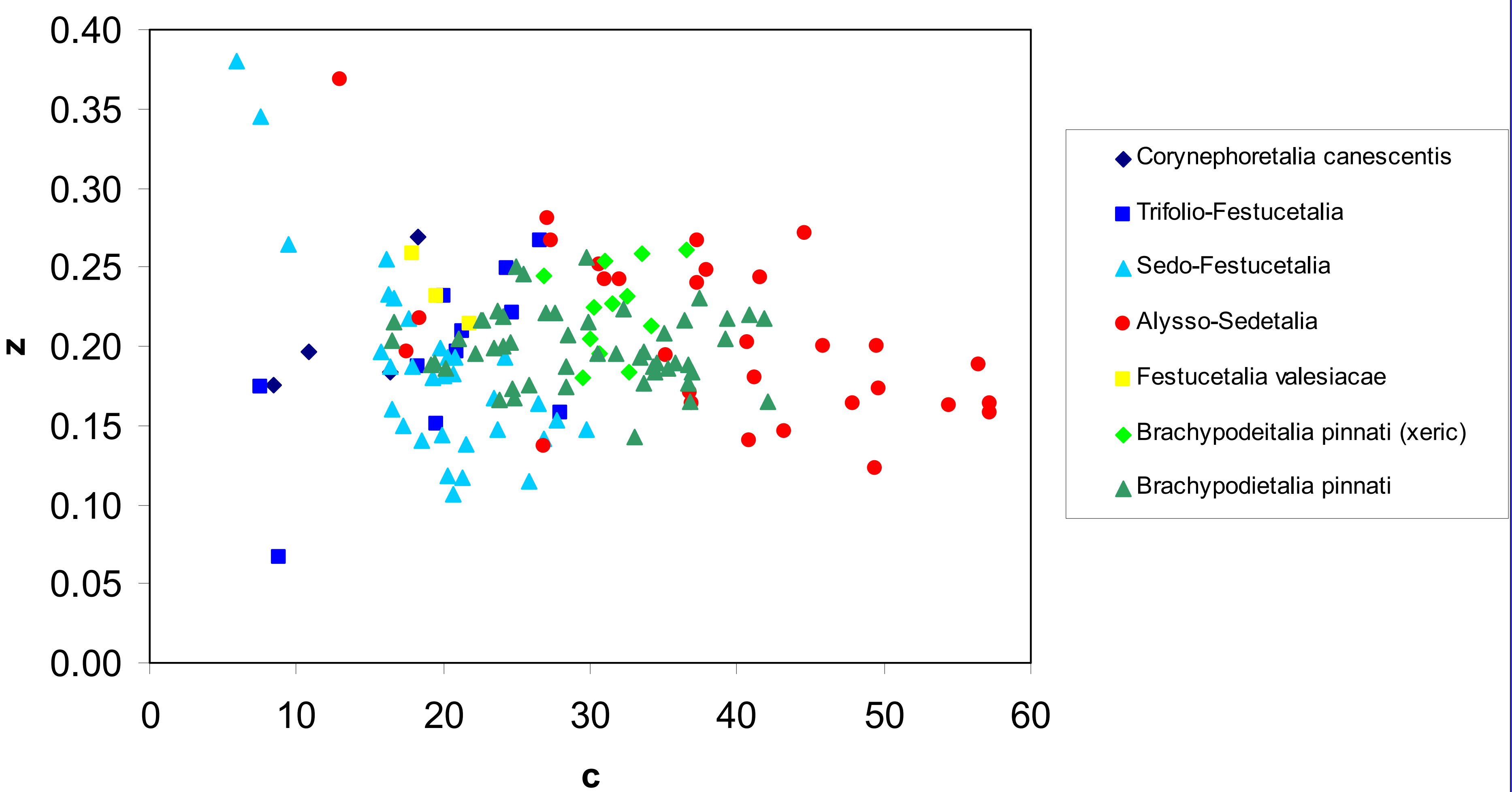
Basic results

► Function parameters

	Mean ± SD	Min	Max
c	28.1 ± 10.5	5.9	57.2
z	0.200 ± 0.045	0.067	0.380

► **Interdependence *c* vs. *z***: R^2 = 0.02 n.s.

Species-area relationships of different vegetation types



Species-area relationships of different vegetation types

		n	c		
Koelerio-Corynephorenea	***Corynephoretalia canescentis***	4	13.5	a	
Koelerio-Corynephorenea	***Sedo-Festucetalia***	32	19.5	a	
Festuco-Brometea	***Festucetalia valesiacae***	3	19.8	a	b
Koelerio-Corynephorenea	***Trifolio-Festucetalia***	11	20.0	a	
Festuco-Brometea	***Brachypodietalia pinnati***	51	29.6		b
Festuco-Brometea	***Brachypodietalia pinnati*, xeric**	12	31.6		b c
Sedo-Scleranthenea	***Alysso-Sedetalia***	30	38.9		c

Species-area relationships in different regions

Latitude	Regions	*n*	*c*	*z*
47-49° N	Switzerland & S Germany	52	29.4	0.204
52-54° N	N Germany	14	16.3	0.197
56-59° N	Sweden, Estonia & Russia	77	29.3	0.198

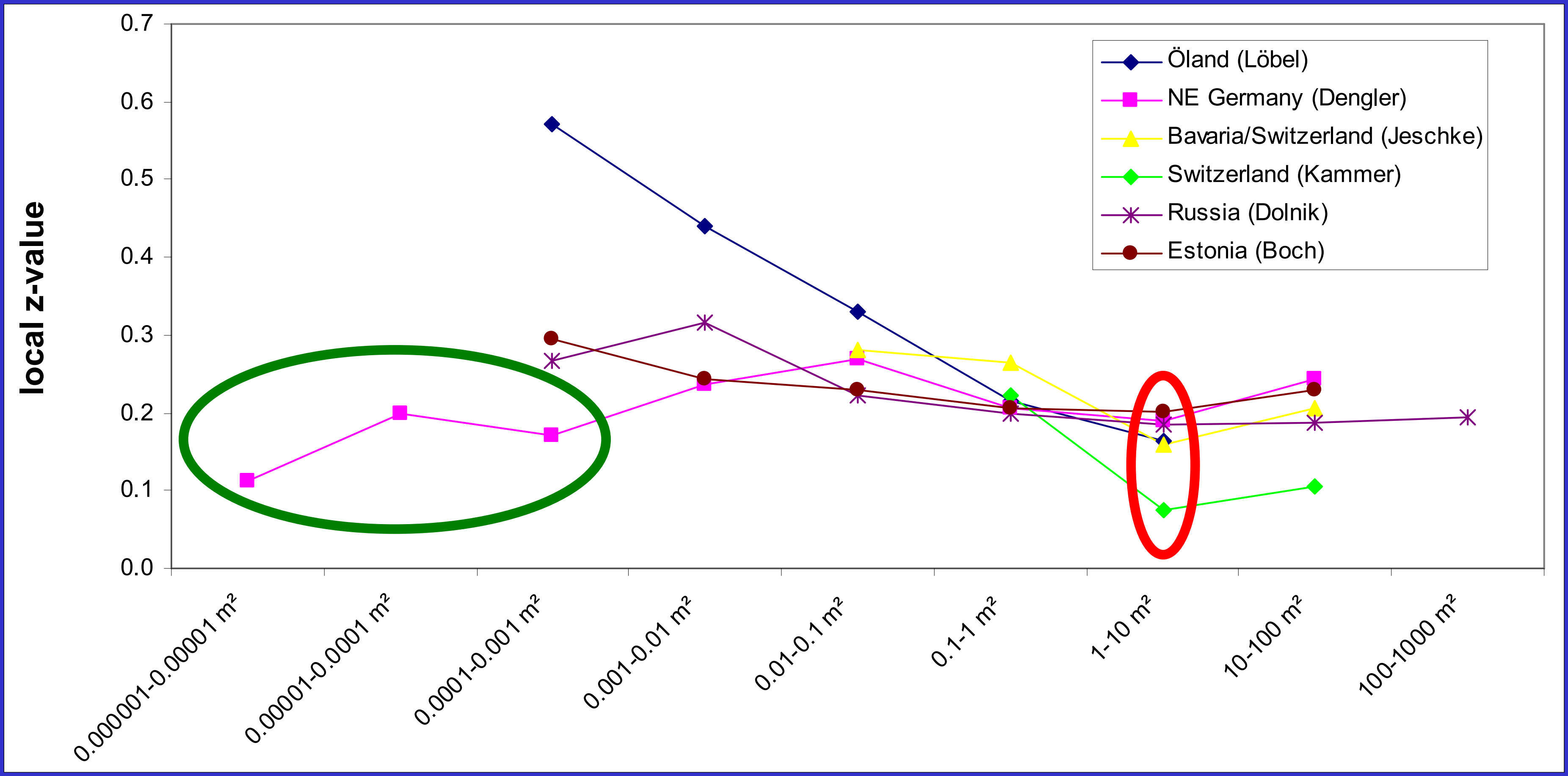
Species-area relationships of different taxonomic groups

► 16 curves from Öland (SE): 0.0001 – 9 m²
16 curves from Saaremaa (EE): 0.0001 – 100 m²

► **z-values:** means ± SE

	All species	***Vascular plants***	***Bryophytes***	***Lichens***
Öland	**0.224** ± 0.013	**0.240** ± 0.015	**0.208** ± 0.038	**0.317** ± 0.036
Saaremaa	**0.219** ± 0.008	**0.214** ± 0.010	**0.173** ± 0.044	**0.380** ± 0.042

Scale-dependency



Conclusions and outlook

► Small-scale (10^{-6} – 10^{4} m^2) SARs are generally best described by power functions. Logarithmic and saturation functions only fit well in few cases and probably due to stochasticity.

► The outcome of SAR analyses depends on the space (S vs. log S) used for the regression itself and for the ‘quality assessment‘ of the derived function.

► Plant diversity is a multidimensional phenomenom and thus cannot be reduced to one single figure.

► Future studies should particularly address the scale-dependency of z-values and the underlying mechanisms.