Benchmarking plant diversity of Palaearctic grasslands

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FORUM

Plant species richness: the world records

J. Bastow Wilson, Robert K. Peet, Jürgen Dengler & Meelis Pärtel

Keywords
Biodiversity; Canonical hypothesis; Macroecology; Oligo- to mesotrophic grassland; Paradox of the Plankton; Power function; Rooted presence; Scale dependence; Shoot presence; Spatial grain; Spatial scale; Species-area relation; Tropical rain forest; World flora

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Abstract

Questions: The co-existence of high numbers of species has always fascinated ecologists, but what and where are the communities with the world records for plant species richness? The species–area relationship is among the best-known patterns in community ecology, but does it give a consistent global pattern for the most saturated communities, the global maxima?

Location: The world.

Methods: We assembled the maximum values recorded for vascular plant species richness for contiguous areas from 1 mm^2 up to 1 ha. We applied the power function to relate maximal richness to area and to make extrapolations to the whole Earth.

Results: Only two community types contain global plant species maxima. The maxima at smaller spatial grain were from oligo- to meso-trophic, managed, semi-natural, temperate grasslands (e.g. 89 species on 1 m^2), those at larger grains were from tropical rain forests (e.g. 942 species on 1 ha). The maximum richness values closely followed a power function with $z = 0.250$: close to Preston's 'canonical' value of 0.262. There was no discernable difference between maxima using rooted presence (i.e. including only plants rooted in the plot) vs shoot presence (i.e. including any plant with physical cover over the plot). However, shoot presence values must logically be greater, with the curves flattening out at very small grain, and there is evidence of this from point quadrats. Extrapolating the curve to the terrestrial surface of the Earth gave a prediction of 219 204 vascular plant species, surprisingly close to a recent estimate of 275 000 actual species.

Conclusions: Very high richness at any spatial grain is found only in two particular habitat/community types. Nevertheless, these high richness values form a very strong, consistent pattern, not greatly affected by the method of sampling, and this pattern extrapolates amazingly well. The records challenge ecologists to consider mechanisms of species co-existence, answers to the 'Paradox of the Plankton'.

Introduction

Very species-rich communities fascinate biologists and challenge them to find world records. For example, Whitmore et al. (1985) claimed that their tropical rain forest plot was much richer than any previously reported. Proctor (1988) dismissed a previous value to assert his value as the record for forest trees and Kull & Zobel (1991, p. 717) reported 'Species richness in the Laelaru wooded meadow is higher than reported in other calcicolous grasslands in Europe'. Moreover, areas with very high richness are often valued as biological conservation hotspots (Myers et al. 2000).

The co-existence of large numbers of species is also of theoretical importance as a challenge to the 'Paradox of the Plankton' (Hutchinson 1961; Wilson 1990, 2011; Palmer 1994). The principle of Gause states that two species occupying the same niche cannot co-exist long term, so how do 942 plant species co-exist in 1 ha of tropical rain forest (Baldev et al. 1998)? Can there be 942 niches? These very rich communities are also those where the controversy on limitations to richness – sometimes saturated

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World record grassland in Transylvania with 98 vascular plant species on 10 m²

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Plant species richness: the world records

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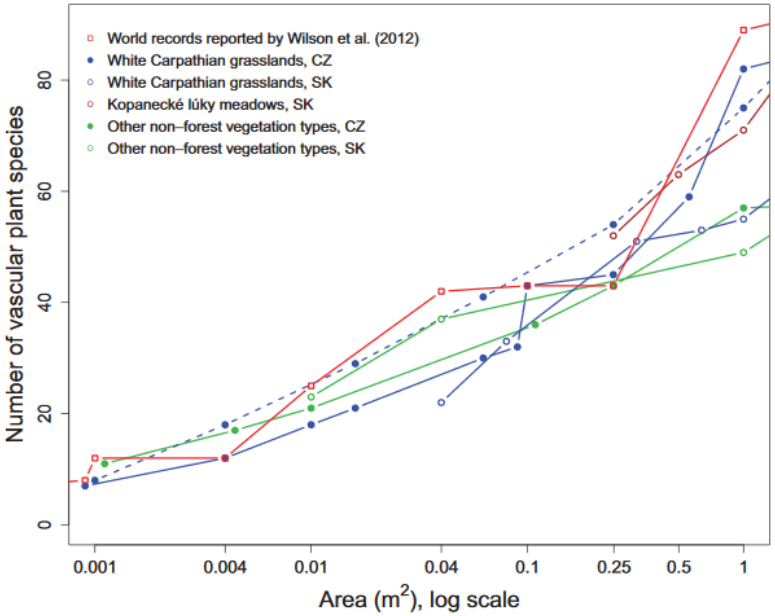
Area (m^2)	Richness	Method	Community	Region	Reference
0.000001	3	shoot	Dry, sandy grassland	Germany	J. Dengler et al. (unpubl.; see Dengler et al. 2004)
0.000009	3	shoot	Dry, sandy grassland	Germany	J. Dengler et al. (unpubl.; see Dengler et al. 2004)
0.0001	5	shoot	Dry, sandy grassland	Germany	J. Dengler et al. (unpubl.; see Dengler et al. 2004)
0.0009	8	rooted	Mountain grassland	Argentina	J.J. Cantero (unpubl.)
0.001	12	shoot	Limestone grassland	Sweden	van der Maarel & Sykes (1993)[1]
0.004	13	rooted	Semi-dry bas. grassland	Czech Republic	Klimeš et al. (2001)
0.01	25	rooted	Wooded meadow	Estonia	Kull & Zobel (1991)
0.04	42	rooted	Wooded meadow	Estonia	Kull & Zobel (1991)
0.1	43	shoot	Semi-dry bas. grassland	Romania	Dengler et al. (2009)
0.25	44	rooted	Semi-dry bas. grassland	Czech Republic	Klimeš et al. (2001)
1	89	rooted	Mountain grassland	Argentina	Cantero et al. (1999)
10	98	shoot	Semi-dry bas. grassland	Romania	Dengler et al. (unpubl.; see Dengler et al. 2009)
16	105	shoot	Semi-dry bas. grassland	Czech Republic	Z. Otýpková (unpubl.)
25	116	shoot	Semi-dry bas. grassland	Czech Republic	Z. Otýpková (unpubl.)
49	131	shoot	Semi-dry bas. grassland	Czech Republic	Z. Otýpková (unpubl.)
100	233	rooted	Tropical lowland rainforest	Costa Rica	Whitmore et al. (1985)
1000	313	rooted	Tropical lowland rainforest	Colombia	Duivenvoorden (1994)
4000	489	rooted	Tropical lowland rainforest	Colombia	Galeano et al. (1998)
10000	942	rooted	Tropical rainforest	Ecuador	Balslev et al. (1998)

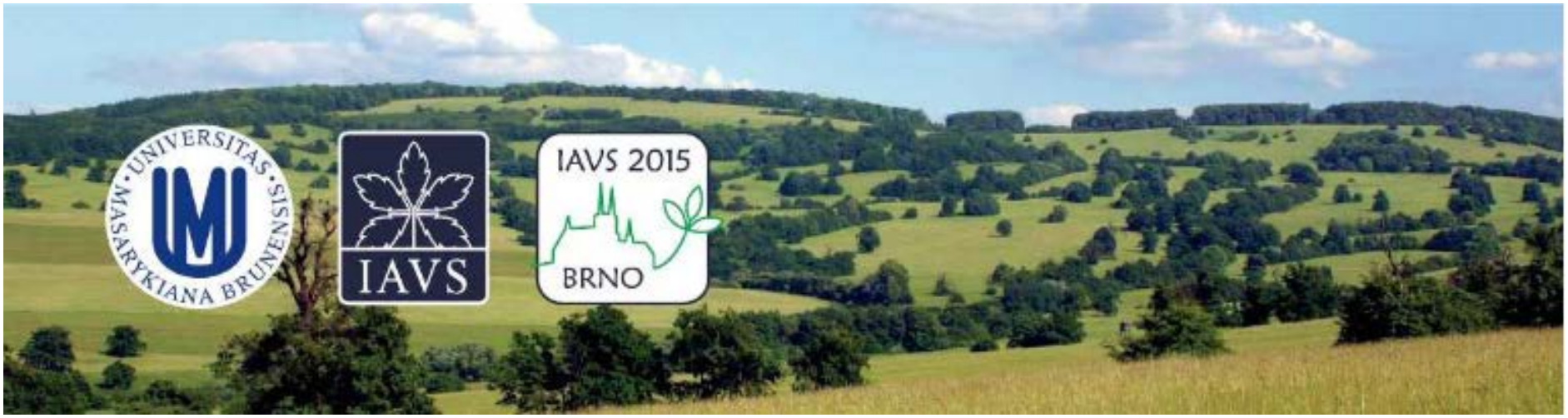
Preslia 87: 217–278, 2015

The most species-rich plant communities in the Czech Republic and Slovakia (with new world records)

Druhově nejbohatší rostlinná společenstva České republiky a Slovenska (s novými světovými rekordy)

Milan Chytrý[1], Tomáš Dražil[2], Michal Hájek[1], Veronika Kalníková[1], Zdenka Preislerová[1], Jozef Šibík[3,4], Karol Ujházy[5], Irena Axmanová[1], Dana Bernátová[6], Drahoš Blanár[7], Martin Dančák[8], Pavel Dřevojan[1], Karel Fajmon[9,10], Dobromil Galvánek[11], Petra Hájková[1,12], Tomáš Herben[13], Richard Hrivnák[3], Štěpán Janeček[14], Monika Janišová[3], Šárka Jiráská[15], Ján Kliment[6], Judita Kochjarová[3,6], Jan Lepš[16], Anna Leskovjanská[17], Kristina Merunková[1], Jan Mládek[8], Michal Slezák[18], Ján Šeffer[19], Viera Šefferová[19], Iveta Škodová[3], Jana Uhlířová[20], Mariana Ujházyová[21] & Marie Vymazalová[1]





Research paper

Scale-dependent plant diversity in Palaearctic grasslands: a comparative overview

Jürgen Dengler[*,1,2], *Idoia Biurrun*[3], *Iva Apostolova*[4], *Esther Baumann*[1], *Thomas Becker*[5], *Asun Berastegi*[6], *Steffen Boch*[7], *Laura Cancellieri*[8], *Iwona Dembicz*[9], *Yakiv P. Didukh*[10], *Christian Dolnik*[11], *Nikolai Ermakov*[12], *Goffredo Filibeck*[8], *Itziar Garcia-Mijangos*[3], *Gianpietro Giusso del Galdo*[13], *Riccardo Guarino*[14], *Monika Janišová*[15], *Renaud Jaunatre*[16], *Kai Jensen*[17], *Michael Jeschke*[18], *Zygmunt Kącki*[19], *Łukasz Kozub*[9], *Anna A. Kuzemko*[20], *Swantje Löbel*[21,22], *Hristo Pedashenko*[4], *Mariya Polyakova*[12], *Eszter Ruprecht*[23], *Anna Szabó*[24], *Kiril Vassilev*[4], *Nikolay Velev*[4], *Frank Weiser*[1]

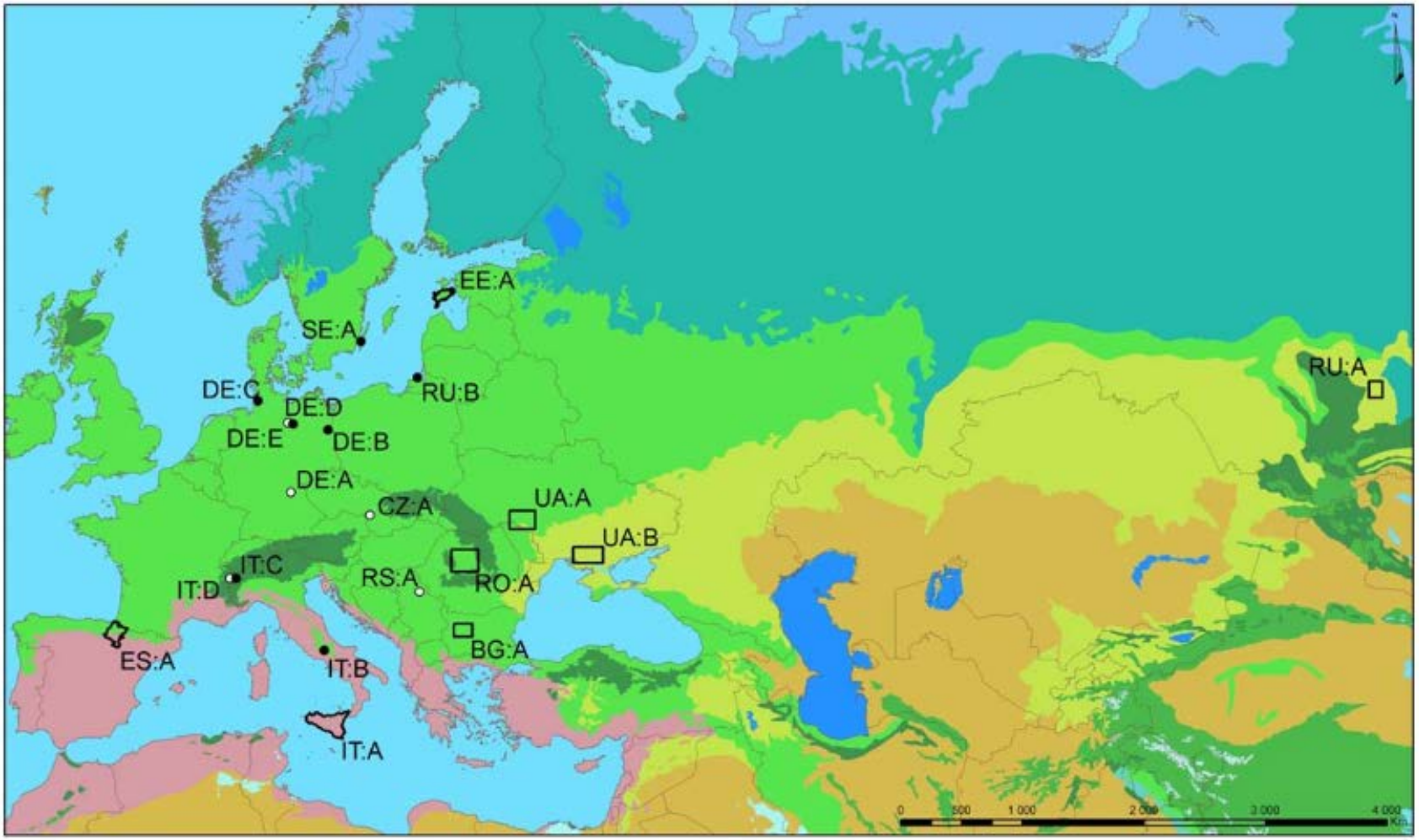
Mean, maximum and minimum values

Total vegetation, vascular plants, bryophytes and lichens

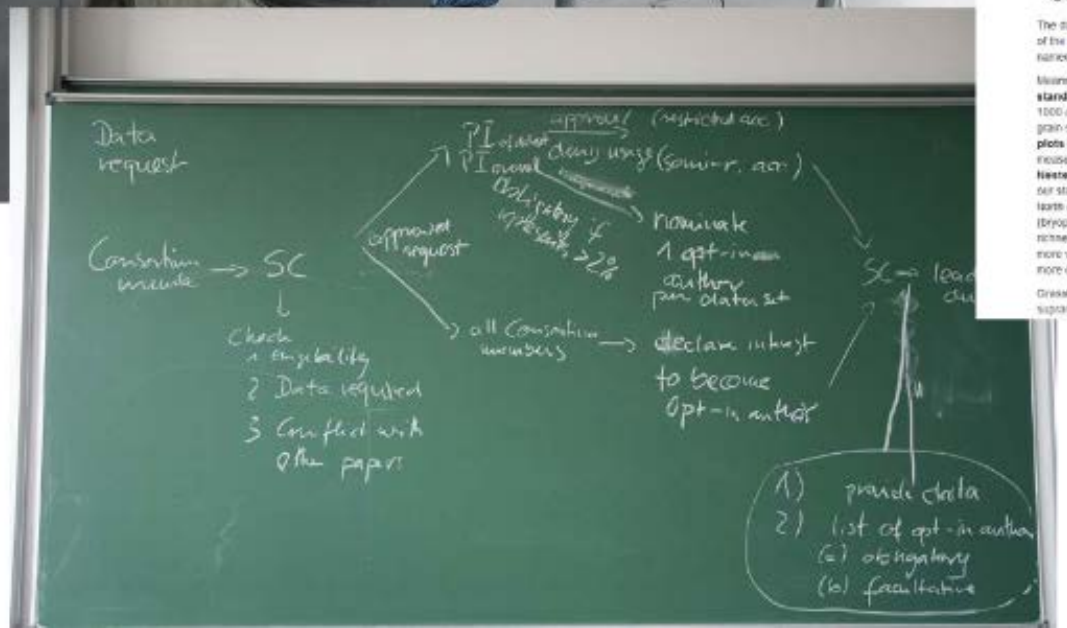
Seven standard grain sizes, from 1 cm^2 to 100 m^2

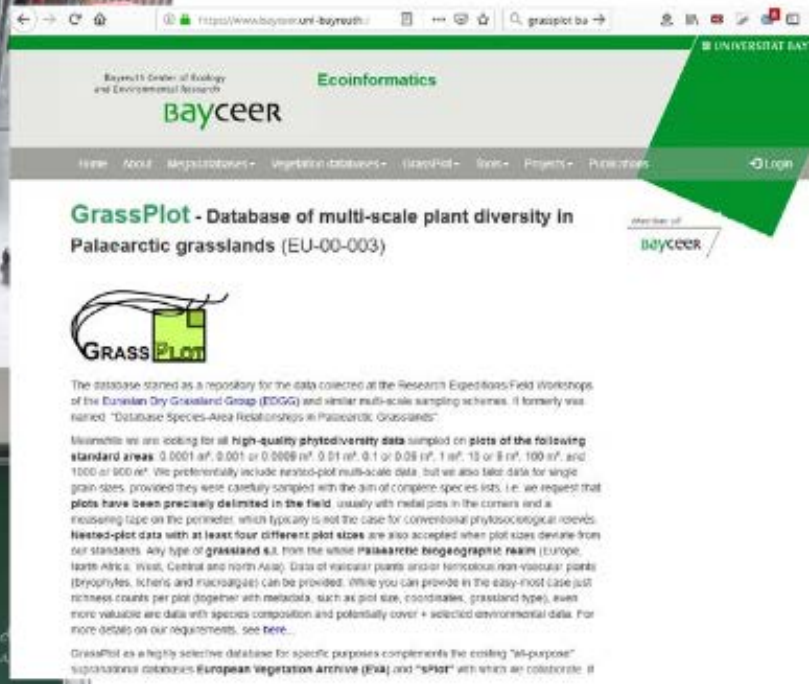
Data from EDGG Field Workshops and similar studies

Plots aggregated at study level for mean calculation



GrassPlot Workshop 6-10 March 2017





https://bit.ly/2HvVkgu

Dengler et al.

Phytocoenologia Vol. 48 (2018), Issue 3, 331–347
Published online May 2018

Long Database Report

GrassPlot – a database of multi-scale plant diversity in Palaearctic grasslands

Nº plots: **190,673**

Nº nested series with at least four grain sizes: **4656**

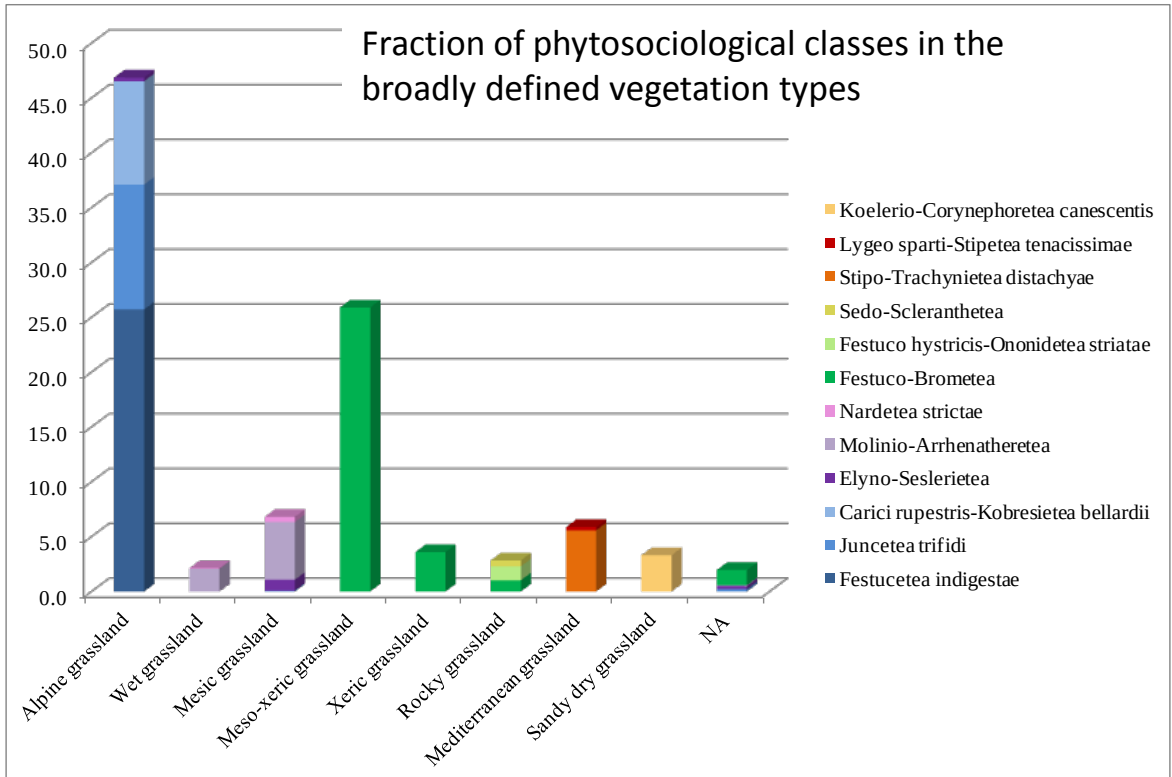
Plots assigned to 17 vegetation types, biomes and regions

Composition data

Land use data

Environmental data

Structural data



Aims

Mean, minimum and maximum values of species richness of Palaearctic grasslands for eight grain sizes:
0.0001 m2, 0.001 m2, 0.01 m2, 0.1 m2, 1 m2, 10 m2, 100 m2 and 1000 m2

Richness values for vascular plants, bryophytes and lichens, as well as for total vegetation

Allow plot aggregation for mean calculation by geographic grid, vegetation type, biome and/or biogeographic region

Implement an online tool for richness data visualization

Data compilation

118,912 plots of standard grain sizes

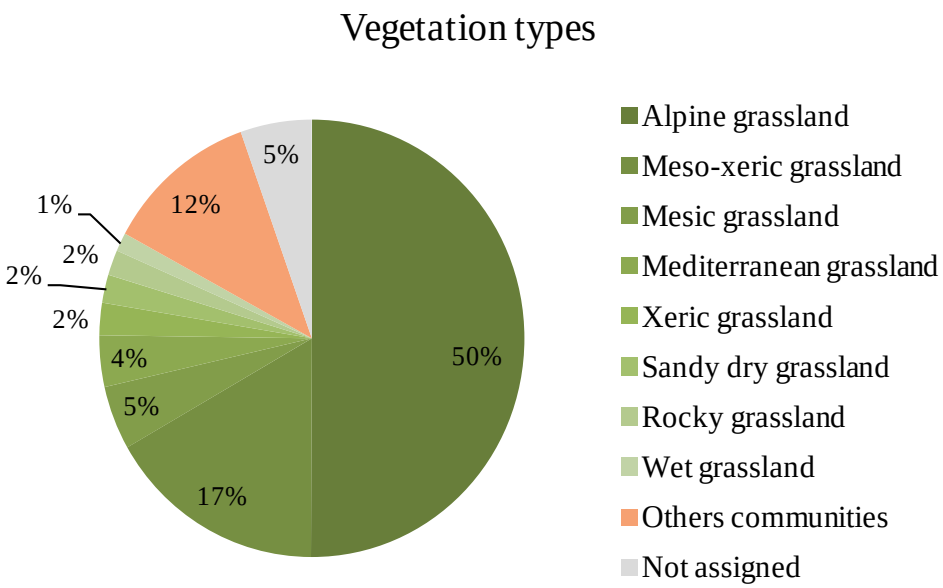
117,766 plots from GrassPlot database

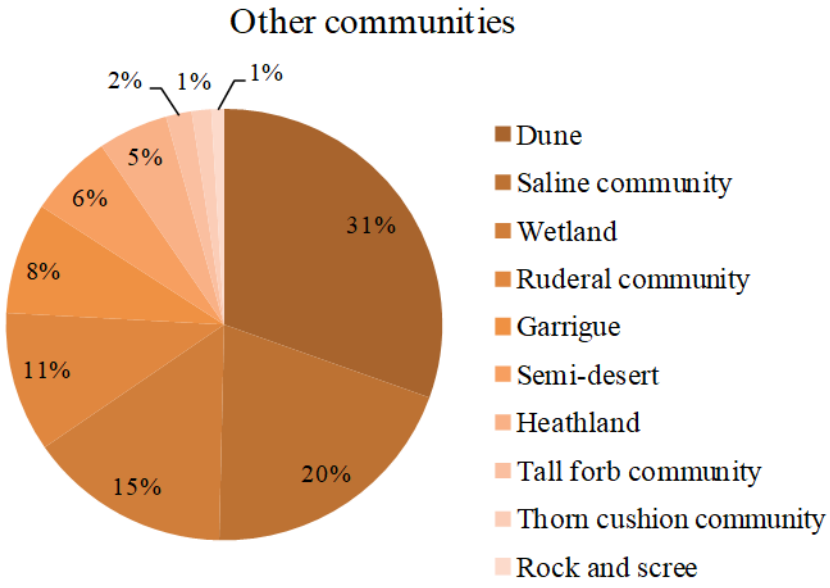
1,146 additional plots from M. Chytrý

Plot distribution across the standard sizes

Grain size (m^2)	Nº plots
0.0001	2536
0.001 (and 0.0009)	3840
0.01	69527
0.1 (and 0.09)	4965
1	22267
10 (and 9)	9967
100	5623
1000 (and 900 and 1024)	187

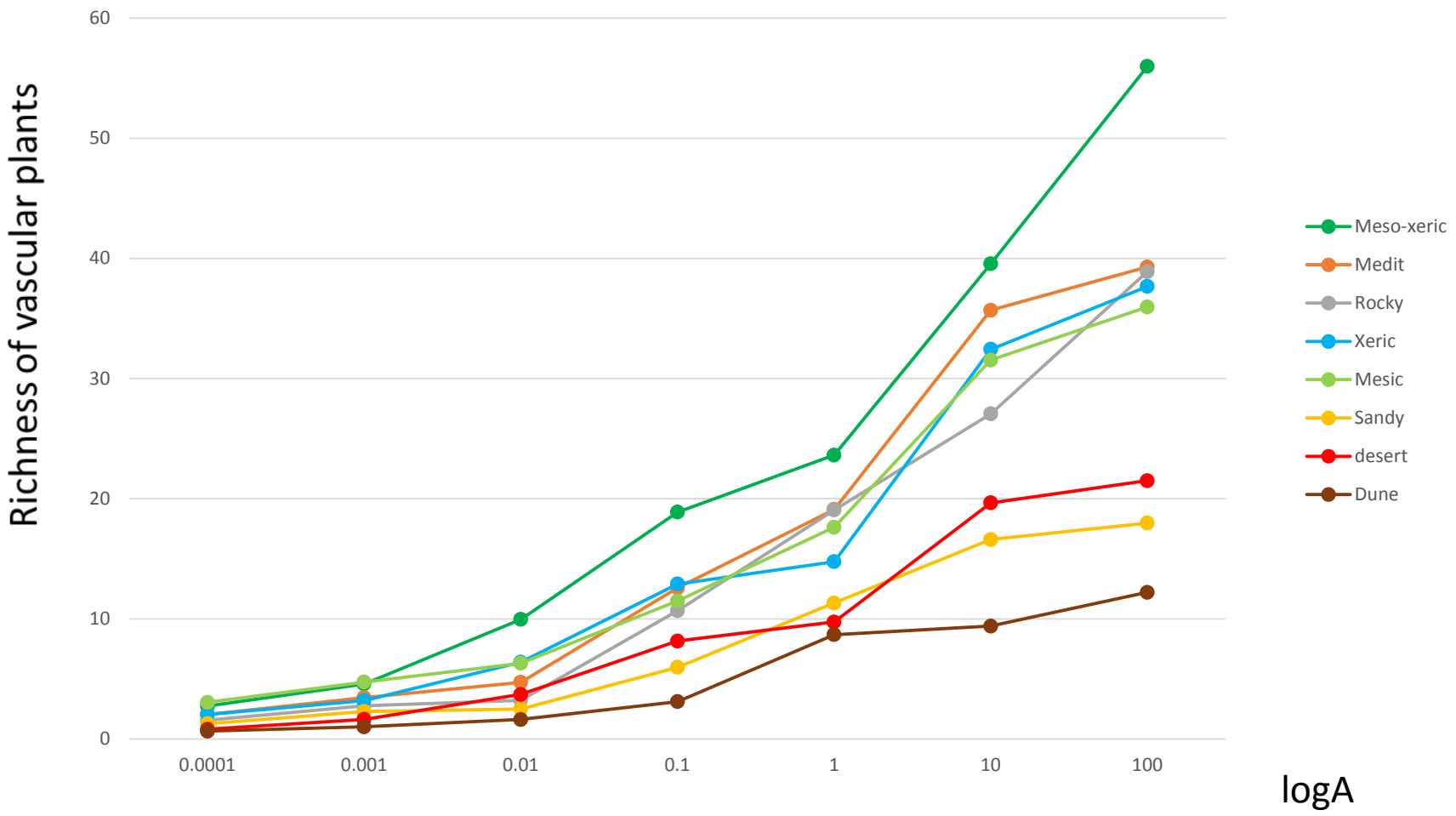

Photo: Salza Palpurina


Vegetation types
50%
17%
5%
4%
2%
2%
1%
2%
12%
5%
Alpine grassland
Meso-xeric grassland
Mesic grassland
Mediterranean grassland
Xeric grassland
Sandy dry grassland
Rocky grassland
Wet grassland
Others communities
Not assigned

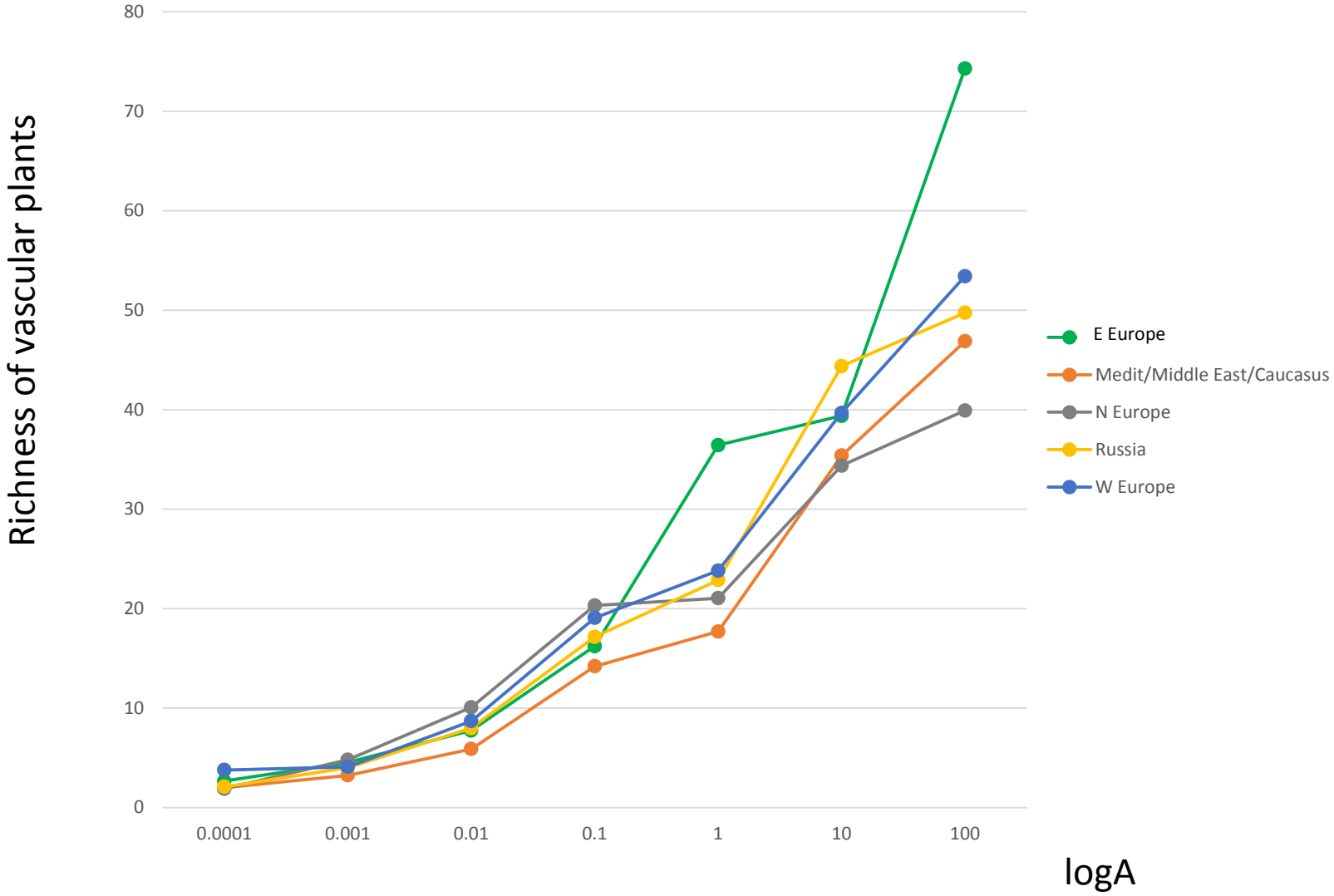

Other communities
31%
20%
15%
11%
8%
6%
5%
2%
1%
1%
Dune
Saline community
Wetland
Ruderal community
Garrigue
Semi-desert
Heathland
Tall forb community
Thorn cushion community
Rock and scree

RESULTS

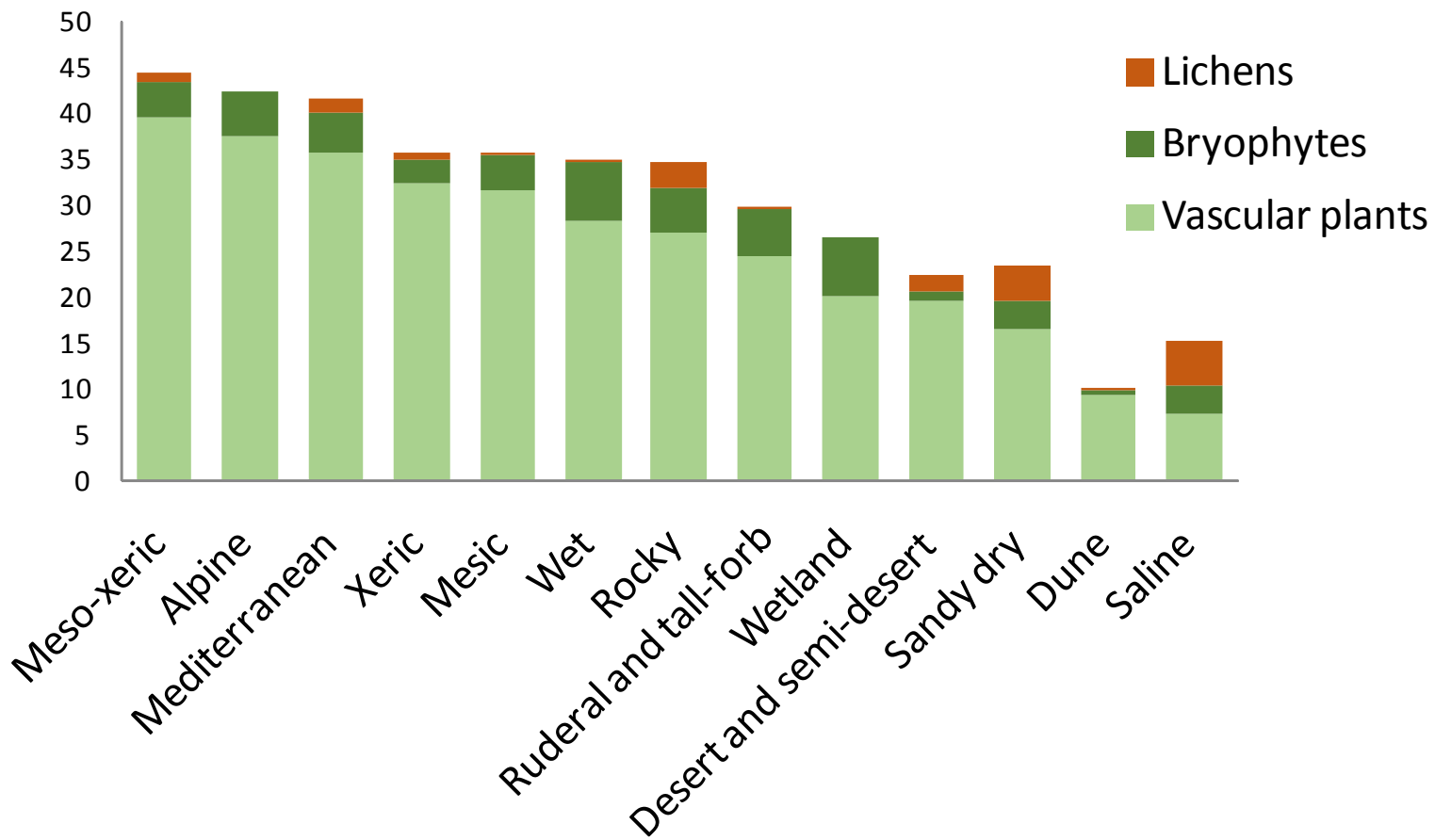
Mean richness of vascular plants for the standard grain sizes



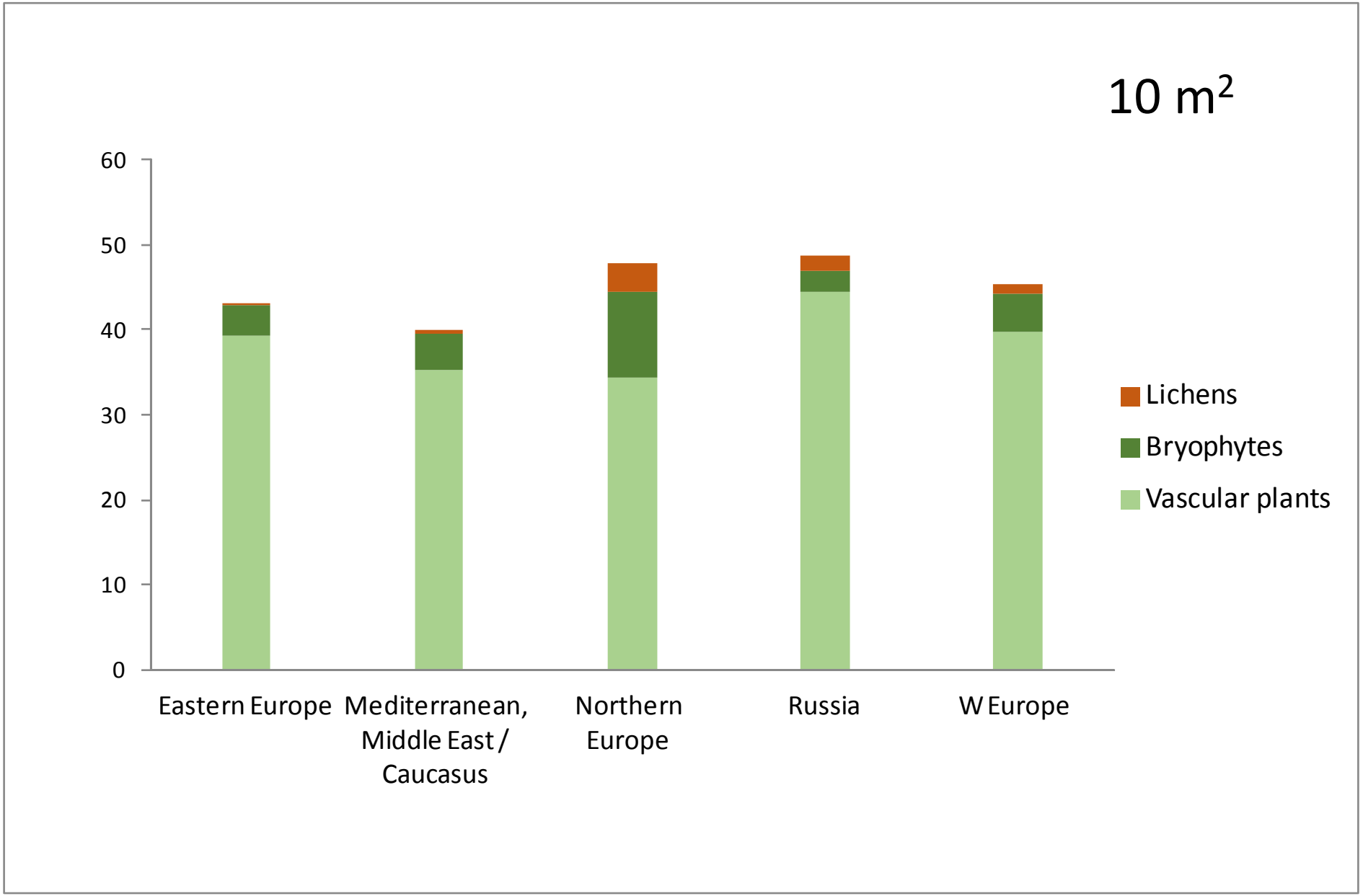
Richness of meso-xeric grasslands: differences across regions



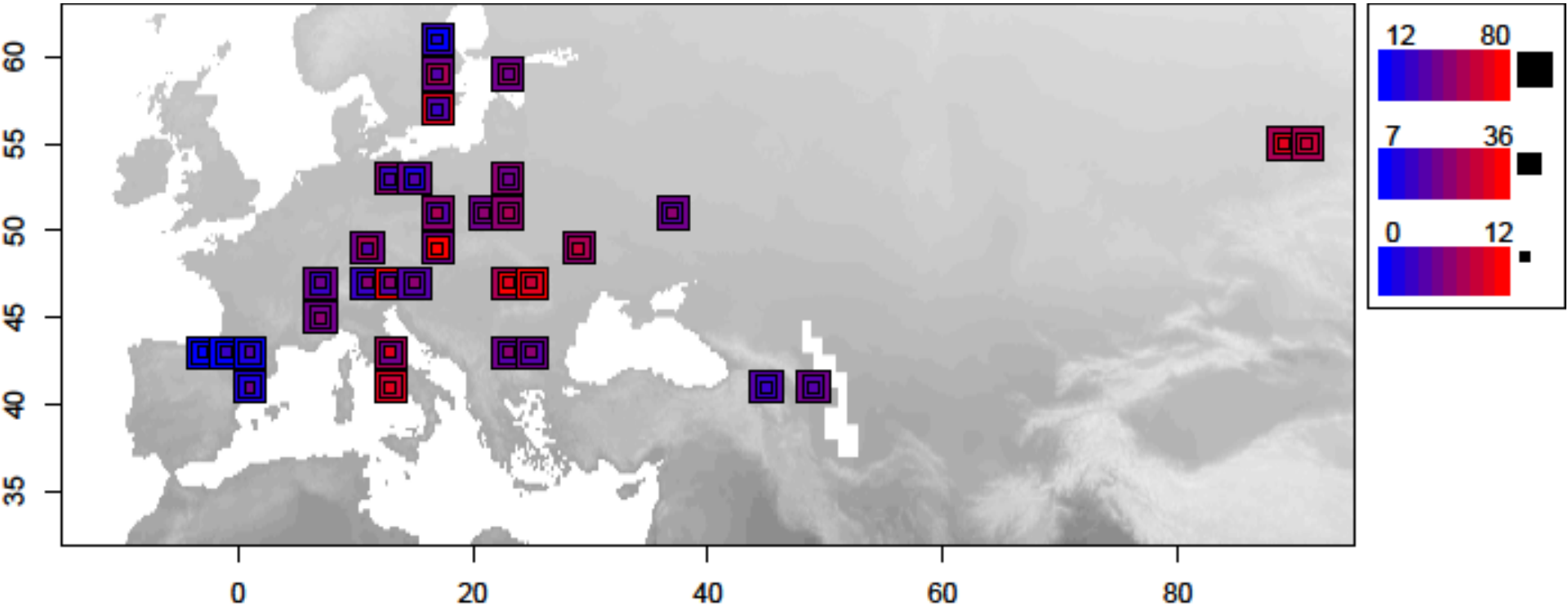
Fraction of vascular plantas, bryophytes and lichens in mean richness values of Palaearctic grasslands at 10 m^2



Example for meso-xeric grasslands across regions



Spatial distribution of mean richness of vascular plants for meso-xeric grasslands across three grain sizes: 0.01, 1 and 100 m^2



Online tool for visualization of richness data

Remek Pielech

GrassPlot database (v. 1.35) | Richness in vegetation types | Richness in biomes | Descriptive statistics | Map

Choose plot size [m2]:

○ 0.0001 ○ 0.001 ◉ 0.01 ○ 0.1 ○ 1 ○ 10 ○ 100 ○ 1000

Select group of organisms:

Vascular

Select biome (Schultz modified with Körner):

Alpine, Boreal zone, Dry midlatitudes, Dry tropics

Select biome (Encyclopedia of Biomes):

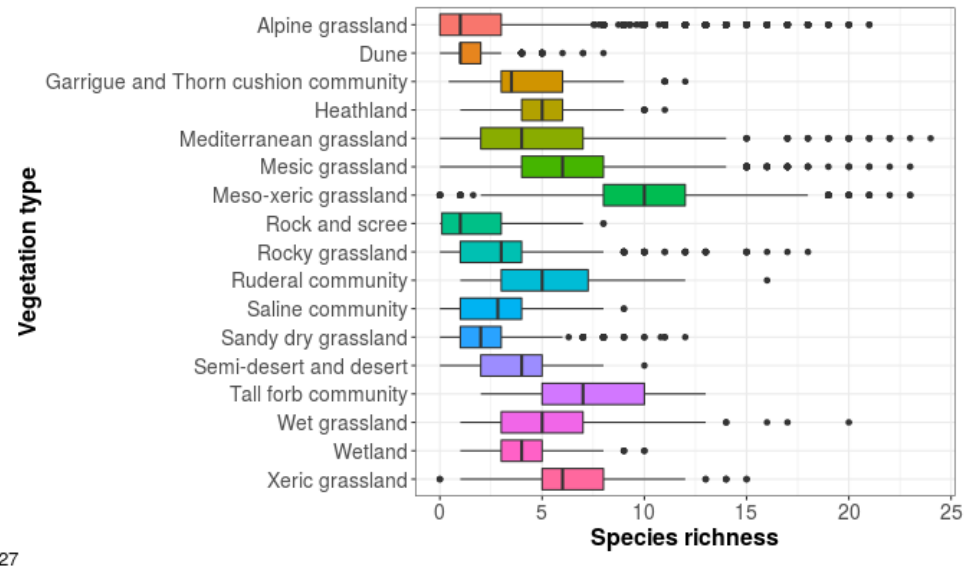
China, Eastern Europe, Japan and Korea, Kazakh

Select region (Squires et al. 2018):

China and Mongolia, Eastern Europe, Japan, Kaz

Select country:

AD, AM, AT, AZ, BA, BE, BG, BY, CH, CN, CZ, DE,



number of plots = 69527

Call for data contribution to GrassPlot database

Precisely delimited and carefully sampled to achieve completness

Plot size: 0.0001 m2, 0.001 m2, 0.01 m2, 0.1 m2, 1 m2, 10 m2, 100 m2, 1000 m2

Nested series with at least four grain sizes

Vascular plants, but bryophytes and lichens also welcomed

Geographic coordinates

Environmental data

Composition data

Consortium bylaws and other relevant information in **https://bit.ly/2HvVkgu**


Thank you!