Large-scale classification of dry grasslands and related communities: approaches, problems, solutions, and first results

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   - German *Arbeitsgruppe Trockenrasen*
   - *Working Group on Dry Grasslands in the Nordic and Baltic Region*
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Introduction: the wider context

Phytosociological (relevé) data:

- In Europe, presumably > 3.1 million relevés exist, of which > 1.4 million are already computerized (Schaminée, Hennekens, Chytrý & Rodwell; presentation at EVS meeting 2008)
- There are some large national databases: Netherlands (400,000 rel.); Czech Republic (70,000 rel.), UK (35,000 rel.)
- Other countries lack such comprehensive databases of all vegetation types, because of:
  - lacking phytosociological tradition (e.g. northern Europe)
  - federalism despite a strong phytosociological tradition (e.g. Germany)

Vegetation classification

- Sound vegetation classification provides meaningful entities both for pure and applied sciences
- European vegetation legislation (Habitats directive, EUNIS) largely rely on phytosociological units although a consistent European classification is so far not available
  - the "distribution" of many units stops at country borders
  - many units are only vaguely defined
- A first overview of European vegetation types down to alliance level exists, but is not backed up by tables etc:

Rodwell, J. S., Schaminée, J. H. J., Mucina, L., Pignatti, S., Dring, J., Moss, D. (2002): The Diversity of European Vegetation – An overview of phytosocio-logical alliances and their relationships to EUNIS habitats. – Rapp. EC-LNV 2002/054: 168 pp.

► Second, much updated version in prep. (Mucina et al.)

Methods

- **TURBOVEG**: near standard for storage & exchange of vegetation data in Europe
- **JUICE**: free and continuously updated software for the analysis of vegetation data
- Proposal and development of a wide range of new and more objective methods for vegetation classification during the last decade:

reviewed in:
Dengler, J., Chytrý, M., Ewald, J. (2008): Phytosociology. – Jørgensen, S. E., Fath, B. D. [Hrsg.]: Encyclopedia of Ecology: 2767–2779, Elsevier, Oxford

Yet…

- **SynBioSys Europe** has started – but it is still a very long way towards a comprehensive vegetation database of all vegetation types of all European countries.

  Schaminée, J. H. J., Hennekens, S. M., Ozinga, W. A. (2007): Use of the ecological inforamtion system SynBioSys for the analysis of large datasets. – J. Veg. Sci. 18: 463–470.

- None of the new classification methods has been tested at really large geographical scale but they usually have been applied to small countries or federal states.
- Many of the new classification methods are basically supervised classifications that require the prior existence of a widely accepted classification. But such widely accepted classifications do not exist in many countries and they differ much among countries

Thus:

- Dry grasslands could be the model system to develop sound large-scale classifications based on comprehensive vegetation databases

- Dry grasslands are particularly suitable as a model because:
  - they occur in large parts of Europe,
  - they have been intensively studied (many relevés exist!),
  - many scientists are interested in them,
  - they have high significance in nature conservation,
  - they cover wide ecological amplitudes, e.g. regarding degree of naturalness, altitude, soil reaction

Two working groups – two databases

Arbeitsgruppe Trockenrasen (German dry grassland working group)

- Founded in 2004 by Ute Jandt and Jürgen Dengler
- Associated with the ***AK Syntaxonomy*** of the ***Floristisch-soziologische Arbeitsgemeinschaft*** and the ***Reinhold-Tüxen-Gesellschaft (RTG)***
- Aims at:
  - establishing a comprehensive vegetation database of dry grasslands in Germany (***Festuco-Brometea***, ***Koelerio-Corynephoretea***, ***Trifolio-Geranietea***, ***Violetea calaminariae***, ***Seslerietea albicantis***)
  - developing a sound national classification of these
  - and to publish the latter in the series ***„Synopsis der Pflanzengesellschaften Deutschlands“***

Arbeitsgruppe Trockenrasen (German dry grassland working group)

- Platform for **information exchange** on all dry grassland related topics
  - E-mail newsletter
  - Homepage
- **Annual meetings**:
  - 2004 – Lüneburg: *Dry grasslands as biodiversity hotspots*
  - 2005 – Münster: *Observation scales in dry grasslands*
  - 2006 – Halle (cancelled)
  - 2007 – Freising: *Restoration and spontaneous establishment of dry and semi-dry grasslands at traditional and urban-industrial sites*
- **Members**:
  - 130 members
  -- 106 from Germany
  -- 24 from 13 other countries (mostly central Europe)

http://www.biologie.uni-hamburg.de/bzf/syst/ag_trockenrasen/ag_trockenrasen.htm

Working Group on Dry Grasslands in the Nordic and Baltic Region

- Founded 2005 by Jürgen Dengler
- Aims and function similar to German group but restricted to the Nordic and Baltic region (10 countries or parts thereof)
- **Members**:
  - 38 members
  - 10 countries (DE, DK, NO, SE, FI, RU, EE, LV, LT, PL)

http://www.biologie.uni-hamburg.de/bzf/syst/wg_dry_grasslands_nordic/wg_dgnb1_eng.htm

2008:

- First European Dry Grassland Conference jointly organised by both working groups (participants from nine countries)

Outlook…

- Foundation of an ***European Dry Grassland Group***?

German database

- Probably 50,000 or more relevés of the relevant vegetation classes exist
- Thus a well thought-out structure is necessary from the beginning, in particular regarding reference lists for species and header data
- Unfortunately this in combination with the volunteer character of the group led to considerable delays, and the proper database does not yet exist
- In 2008, Florian Jansen and Jürgen Dengler finally compiled a comprehensive up-to-date electronic reference list for all vascular plant, bryophyte and lichen as well as many algal taxa of Germany (**GermanSL1.1**) that can be used in TURBOVEG http://geobot.botanik.uni-greifswald.de/portal/reflist
- Pull-down menus for header data are still in preparation
- Hopefully, the database in TURBOVEG will start by end of 2008 with:
  - approx. 6,000 relevés alread collected by Ute Jandt
  - approx. 2,000 relevés by Jürgen Dengler and his students
  - approx. 3,500 relevés from the database of Mecklenburg-Vorpommern

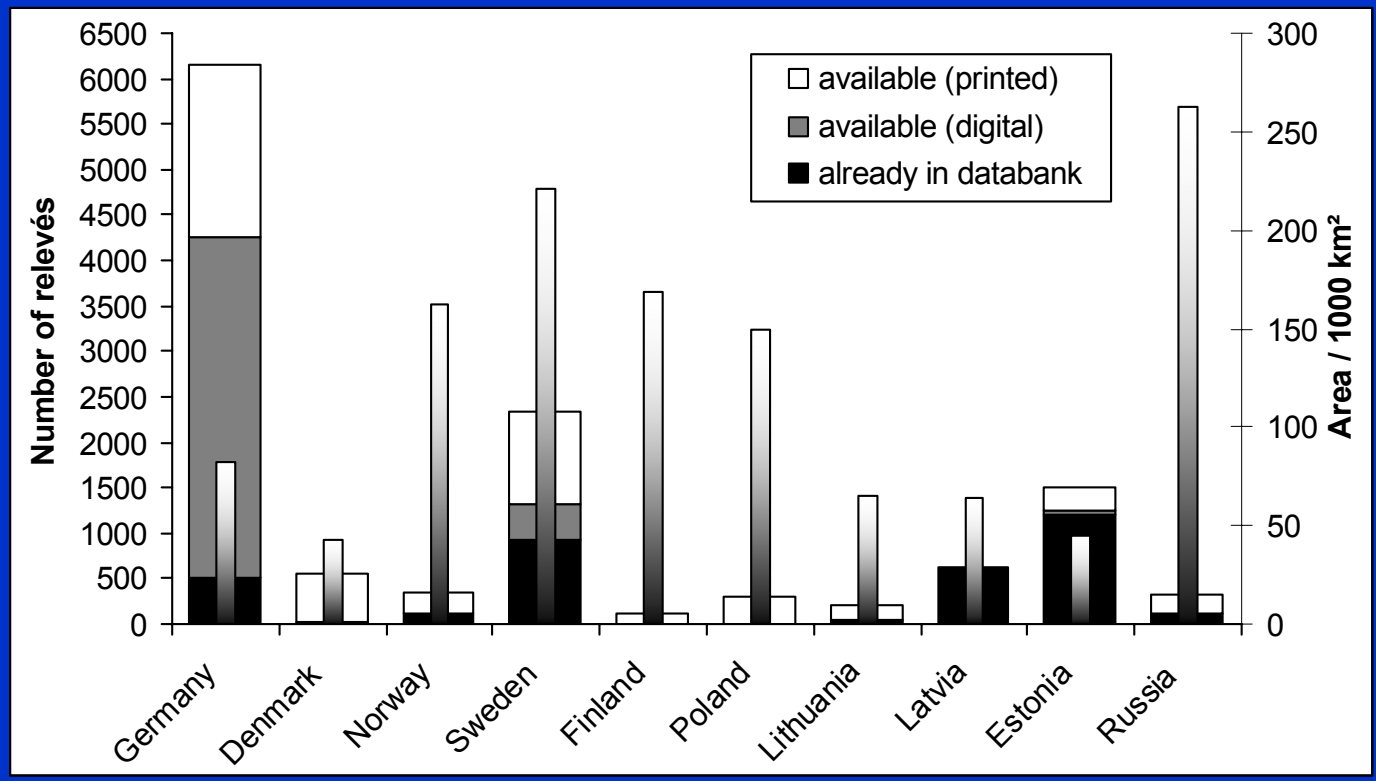
Nordic-Baltic database

- Database less elaborate and therefore already available
- Presently handled with SORT but will be transformed to TURBOVEG soon

Some basic statistics

- According to our overview, ≥ 17,700 relevés exist, of which 7,016 are already included in our database
- Types of "publications":
  - 9 % published relevés
  - 45 % original relevés to published constancy tables
  - 14 % theses and reports ("grey literature")
  - 32 % unpublished relevés

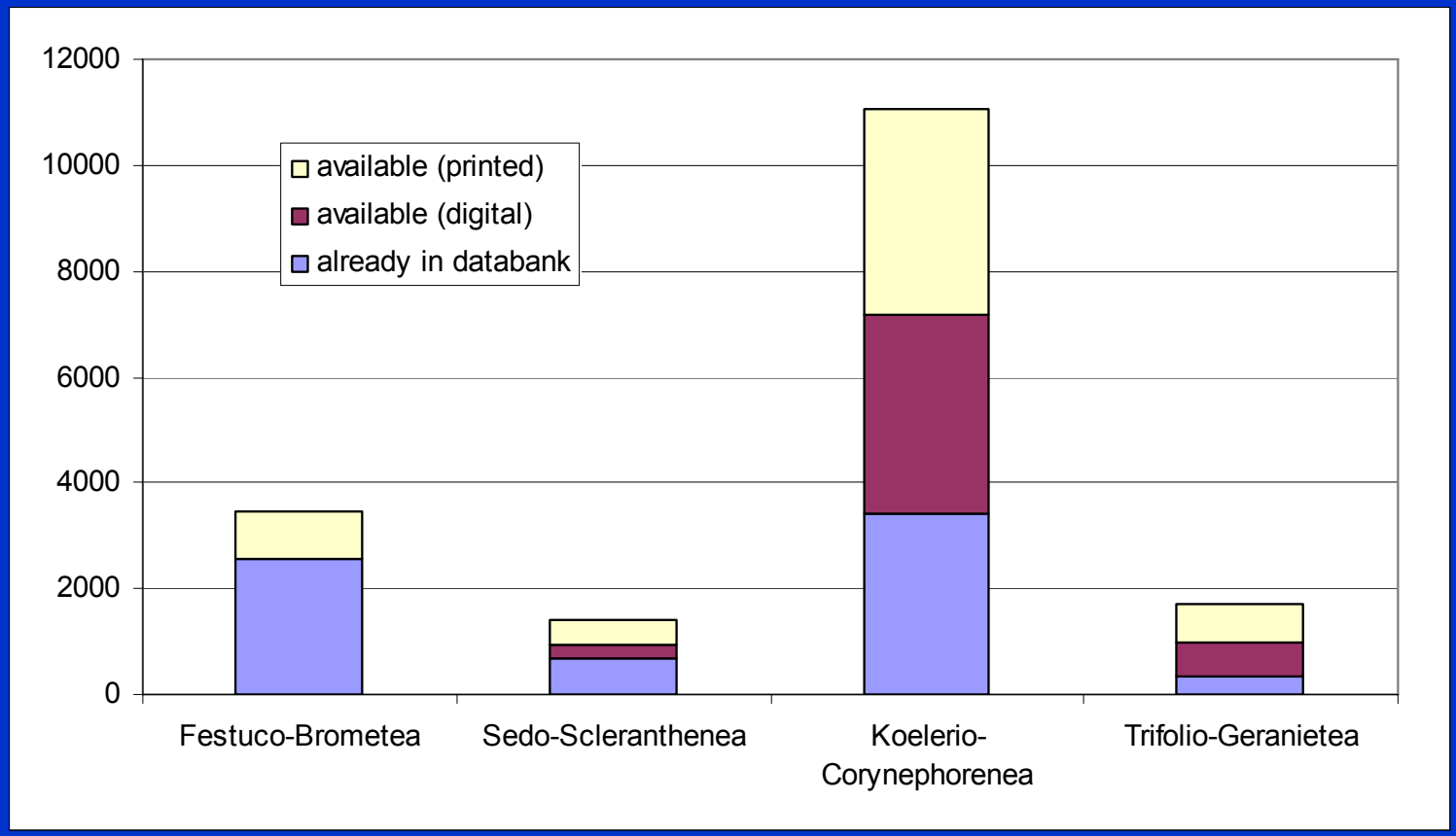
Nordic-Baltic database



From:

Dengler, J., Rūsiņa, S., Boch, S., Bruun, H. H., Diekmann, M., Dierßen, K., Dolnik, C., Dupré, C., Golub, V. B., Grytnes, J.-A., Helm, A., Ingerpuu, N., Löbel, S., Pärtel, M., Rašomavičius, V., Tyler, G., Znamenskiy, S. R., Zobel, M. (2006): Working group on dry grasslands in the Nordic and Baltic region – Outline of the project and first results for the class Festuco-Brometea. – Ann. Bot. N. S. 6: 1–28, Rome.

Nordic-Baltic database



Quality of available data

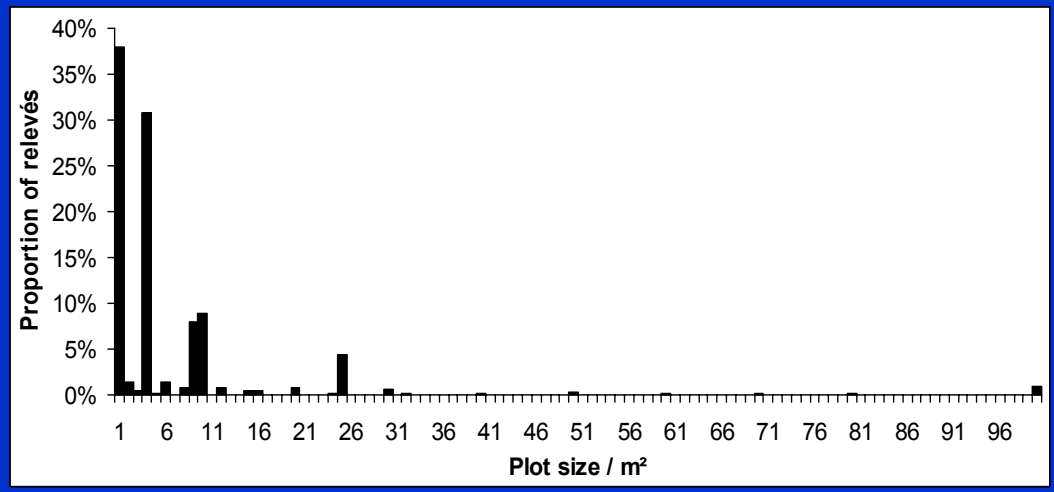
(1) Plot sizes

- Plot sizes used for dry grassland relevés vary widely in **European** countries:

  Koelerio-Corynephoretea: 0.01-200 m²
  Festuco-Brometea: 0.1-100 m²
  Trifolio-Geranietea: 0.5-800 m²

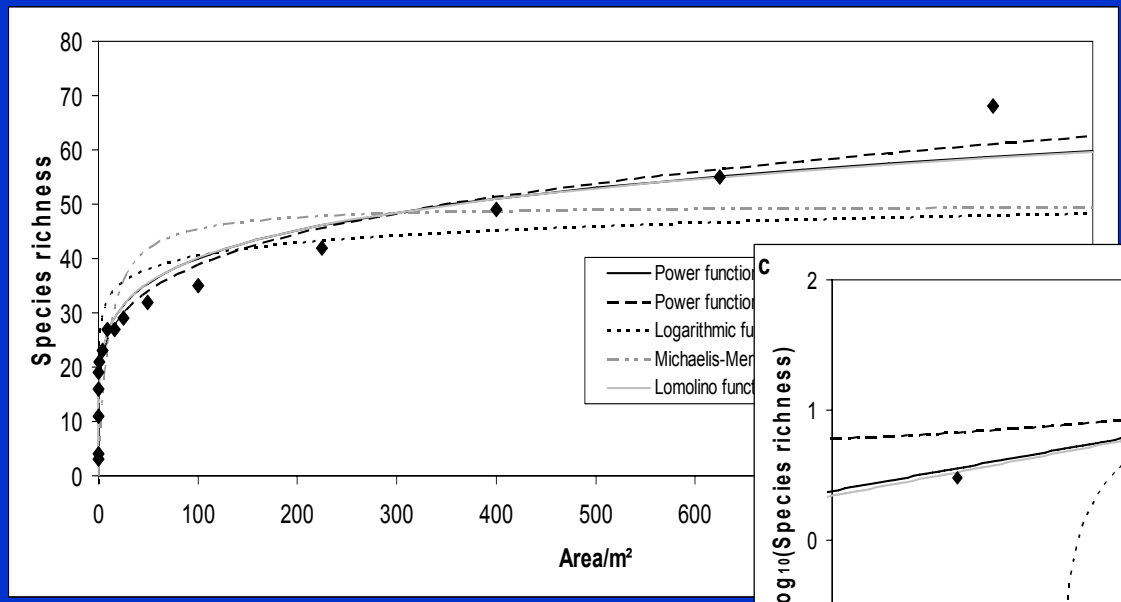
Chytrý, M., Otýpková, Z. (2003): Plot sizes used for phytosociological sampling of European vegetation. – J. Veg. Sci. 14: 563–570.

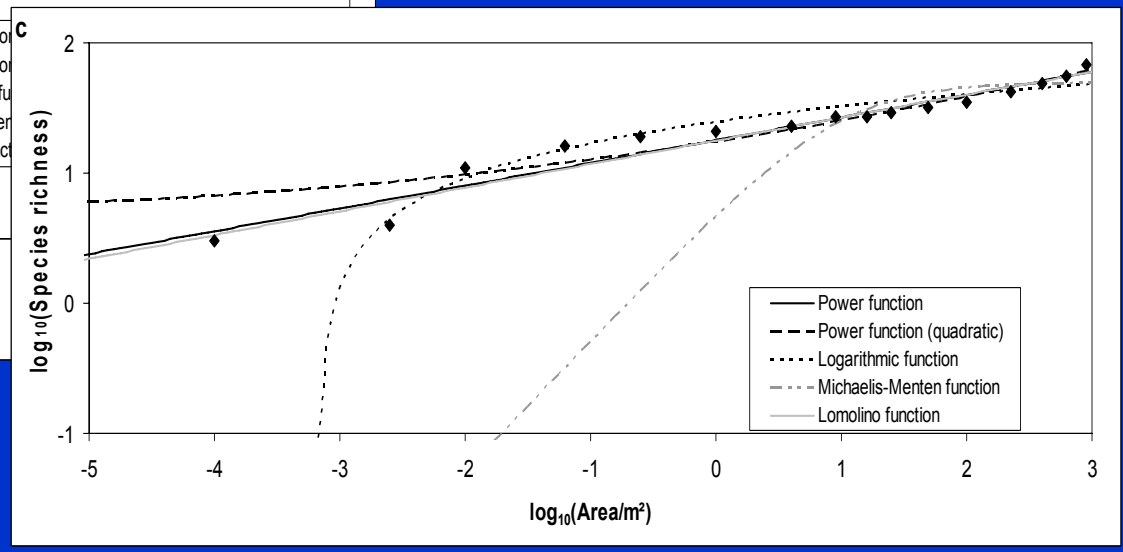
- **Nordic-Baltic region**:
  0.1-3,500 m²



Why to care about plot sizes?

- **Species-area relationship (SAR):**
  Mean species richness always increases with in increasing area (no saturation!)





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

Why to care about plot sizes?

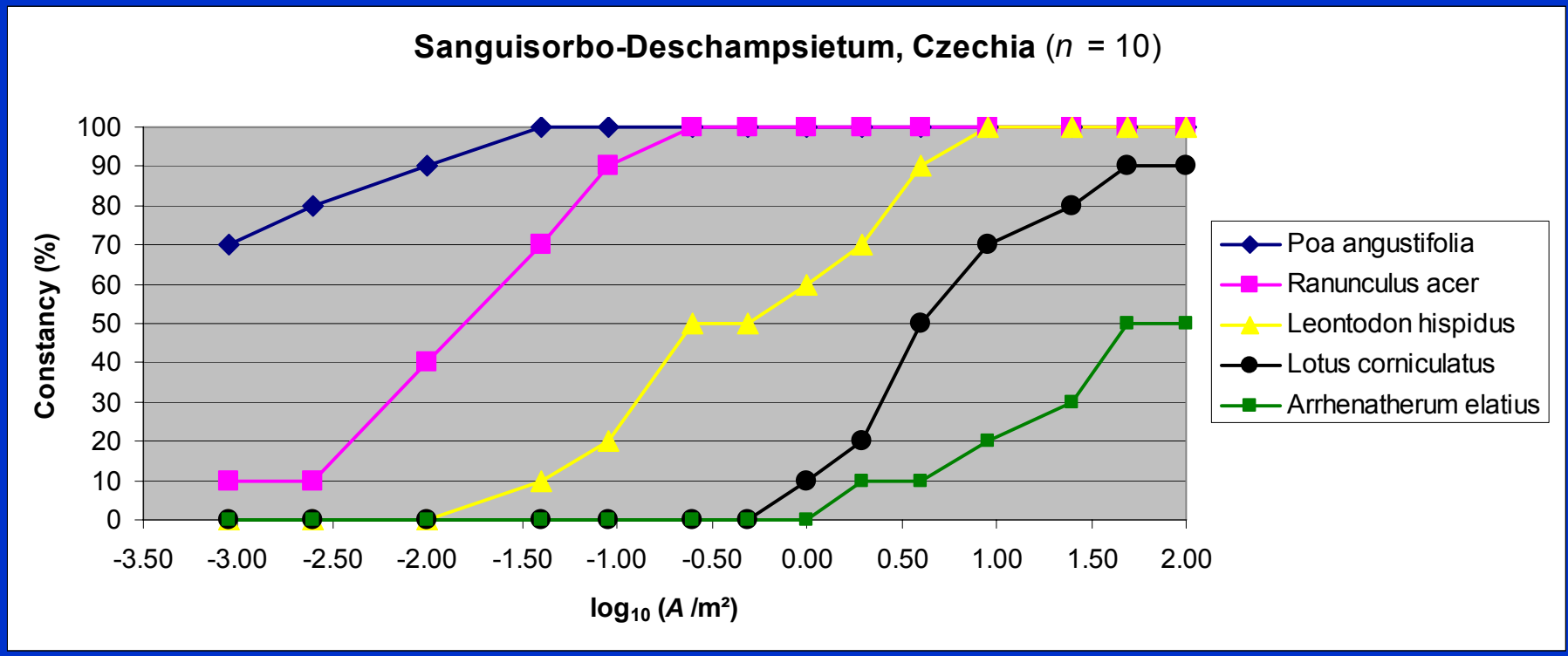
- **Species co-occurrence patterns (ordinations) depend on plot size**

  Otýpková, Z., Chytrý, M. (2006): Effects of plot size on the ordination of vegetation samples. – J. Veg. Sci. 17: 465–472.

- **Species constancy depends on plot size**

  Dengler, J., Löbel, S., Dolnik, C. (submitted): Constancy values depend on plot size – a problem for vegetation classification and how it can be solved. – J. Veg. Sci.

Why to care about plot sizes?



Why to care about plot sizes?

Mean change in constancy when plot size is increased:

Constancy	A_0	2 A_0	4 A_0	8 A_0	16 A_0	32 A_0	64 A_0
	0.05	0.07	0.11	0.16	0.24	0.34	0.47
	0.10	0.15	0.22	0.31	0.43	0.57	0.72
	0.15	0.22	0.31	0.43	0.58	0.73	0.86
	0.20	0.29	0.40	0.54	0.69	0.83	0.93
	0.25	0.35	0.48	0.63	0.78	0.90	0.97
	0.30	0.42	0.56	0.71	0.85	0.94	0.99
	0.35	0.48	0.63	0.78	0.90	0.97	0.99
	0.40	0.54	0.69	0.83	0.93	0.98	1.00
	0.45	0.60	0.75	0.88	0.96	0.99	1.00
	0.50	0.65	0.80	0.91	0.97	1.00	1.00
	0.55	0.70	0.84	0.94	0.99	1.00	1.00
	0.60	0.75	0.88	0.96	0.99	1.00	1.00
	0.65	0.80	0.91	0.97	1.00	1.00	1.00
	0.70	0.84	0.94	0.98	1.00	1.00	1.00
	0.75	0.88	0.96	0.99	1.00	1.00	1.00
	0.80	0.91	0.98	1.00	1.00	1.00	1.00
	0.85	0.94	0.99	1.00	1.00	1.00	1.00
	0.90	0.97	0.99	1.00	1.00	1.00	1.00
	0.95	0.99	1.00	1.00	1.00	1.00	1.00

- **Classification is only reasonable for identical or at least similar plot sizes (because fidelity is based on constancy ratios)**

(2) "Cryptogams"

- **Bryophytes and lichens are often not or only insufficiently recorded**

- **However, they should be included in the analyses in vegetation types in general, but particularly in dry grasslands because**
  - they contribute a major proportion to total plant diversity
  - they have a high diagnostic value

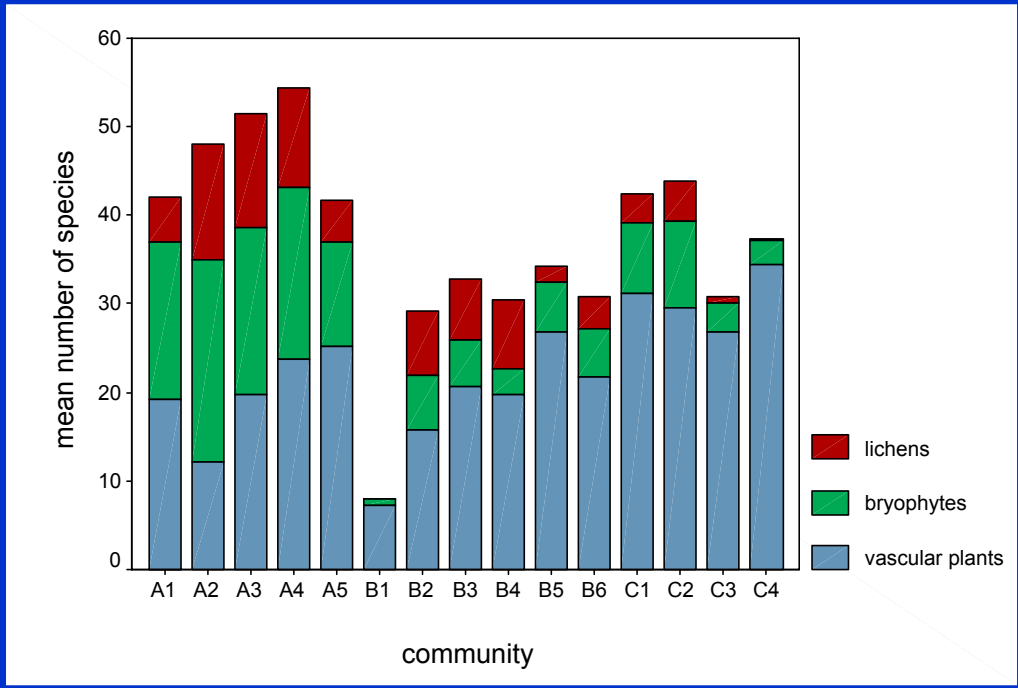
<u>See:</u>

Berg, C., Dengler, J. (2005): Moose und Flechten als diagnostische Arten von Pflanzengesellschaften – eine Übersicht aus Mecklenburg-Vorpommern. – Herzogia 18: 145–161, Halle (Saale).

Dengler, J. (2005): Zwischen Estland und Portugal – Gemeinsamkeiten und Unterschiede der Phytodiversitätsmuster europäischer Trockenrasen. – Tuexenia 25: 387–405, Göttingen.

(2) “Cryptogams”

Mean proportion of plant groups in dry grassland types of the island of Öland at the 4-m² scale



See:

Löbel, S., Dengler, J. (2008) [„2007”]: Dry grassland communities on southern Öland: phytosociology, ecology, and diversity. – In: Maarel, E. van der [Ed.]: Structure and dynamics of alvar vegetation on Öland and some related dry grasslands – Dedicated to Ejvind Rosén on his 65th birthday. – Acta Phytogeogr. Suec. 88: 13–31, Svenska Växtgeografiska Sällskapet, Uppsala.

(3) Incomplete relevés

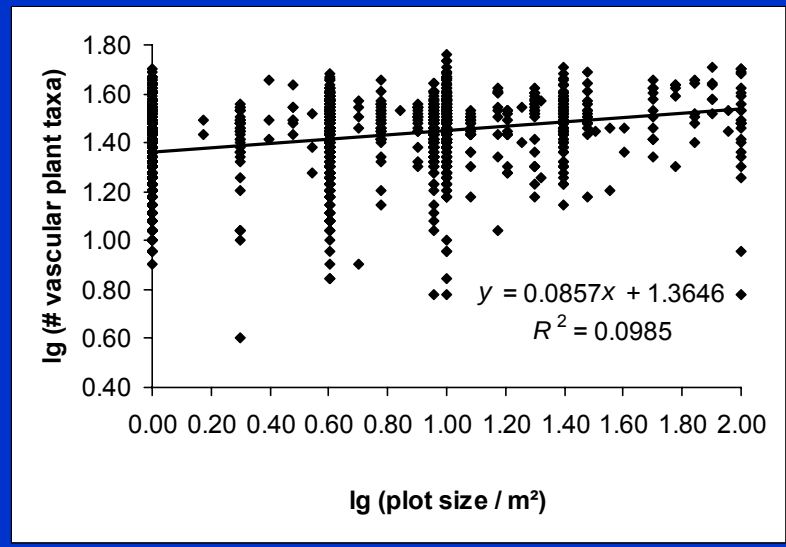
- Relevés without plot size given
- Relevés withouth geographic coordinates or locality

► **Such relevés are practically useless**

- **Species lists of larger plot sizes tend to be rather incomplete**

z-values of basiphilous semi-dry grassland:

0.20 in nested-plots
0.09 in Nordic-Baltic database



See also:

Chytrý, M. (2001): Phytosociological data give biased estimates of species richness. – J. Veg. Sci. 12: 439–444, Uppsala.

(4) Spatial aggregation of plots

- Phytosociological data in databases tend to be spatially clumped, i.e. many relevés originate from local/regional studies, while only few or no relevés exist from other areas.
- This may result in seemingly significant species co-occurrence patterns that in fact are only local idiosyncrasies but without general relevance.

► **Geographically stratified resampling may be used to reduce this problem**

See:

Knollová, I., Chytrý, M., Tichý, L., Hájek, O. (2005): Stratified resampling of phytosociological databases: some strategies for obtaining more representative data sets for classification studies. – J. Veg. Sci. 16: 479–486, Uppsala.

Delimitation of the study object

- As long as no comprehensive database & classification of all vegetation types is available for the study area, **ad-hoc methods** are necessary for the selection of which relevé belongs to the dry grasslands (or a specific subtype of these)
- Ad-hoc methods for the assignment of relevés:
  (1) original classification
  (2) cover of diagnostic species
  (3) species-group method
  (4) new approach

(1) Original classification

- **Problems:**
  - Many relevés have not been assigned to any syntaxon by their authors
  - Those authors who have assigned their relevés usually used different superior syntaxa or interpreted them in different ways – thus relying on them would lead to a biased selection

(2) Cover of diagnostic species

- **Example:**
  Selection of semi-dry basiphilous grasslands:
  Bromus erectus or *Brachypodium pinnatum* with cover > 25%

  Illyés, E., Chytrý, M., Botta-Dukát, Z., Jandt, U., Škodová, I., Janišova, M., Willner, W., Hájek, O. (2007): Semi-dry grasslands along a climatic gradient across Central Europe: Vegetation classification with validation. – J. Veg. Sci. 18: 835–846, Uppsala. .

- **Advantage:**
  - Selection criteria are objective and easily repeatable

- **Disadvantage:**
  - Delimitation of the study object does not really correspond to a phytosociological unit:
    - included relevés may not belong to the syntaxon
    - many relevés belonging to the syntaxon are not selected

(3) Species-group method

Bruelheide, H. (1997): Using formal logic to classify vegetation. – Folia Geobot. Phytotaxon. 32: 41–46, Praha.
Bruelheide, H. (2000): A new measure of fidelity and its application to defining species groups. – J. Veg. Sci. 11: 167–178, Uppsala.

- **Advantage:**
  - Diagnostic species and syntaxon delimitation are determined according to statistical criteria within the specific data set
- **Disadvantages:**
  - Result depends on the specific data set
  - Less suitable for “outer delimitation” of the study object when the outside units are hardly represented in the database
  - Method is strongly influenced by plot size (as it relies on fidelities and thus constancies)

(4) New approach

Dengler, J, et al. (2006): Working group on dry grasslands in the Nordic and Baltic region – Outline of the project and first results for the class Festuco-Brometea. – Ann. Bot. N. S. 6: 1–28, Rome.

- **Outline:**
  - For the studied syntaxon and "adjacent" syntaxa of equal rank, ***a priori* (consensus) lists of diagnostic taxa** are compiled from the literature
  - One species can be listed as diagnostic for more than one syntaxon
  - For each relevé the sum of ordinal transform cover values of the diagnostic species of all syntaxa is calculated
  - Each relevé is assigned to that syntaxon with the highest sum of ordinal transform cover values

(4) New approach

Dengler, J, et al. (2006): Working group on dry grasslands in the Nordic and Baltic region – Outline of the project and first results for the class Festuco-Brometea. – Ann. Bot. N. S. 6: 1–28, Rome.

- **Advantages:**
  - Result does not depend on the specific data set
  - Whether adjacent syntaxa are present to a smaller or larger extent in the dataset has no effect
  - Selection criteria are unambiguous and easily repeatable
  - Because of the use of many species for syntaxon delimitation, the result is little influenced by the diagnostic value assigned to a certain species
  - No relevé remains unassigned and none is assigned to more than one syntaxon
  - Method is not or only little influenced by plot size because
    - ratios of species groups are used instead of single species groups
    - cover is used instead of presence

Classification approaches

- **Actual classification within the syntaxon in focus**

- Some “modern” approaches
  (1) Statistical fidelity measures & species-group method
  (2) Modifications of the species-group method
  (3) Validation of a classification
  (4) Approach of Dengler

(1) Statistical fidelity measures & species-group method

Bruelheide, H. (1997): Using formal logic to classify vegetation. – Folia Geobot. Phytotaxon. 32: 41–46, Praha.
Bruelheide, H. (2000): A new measure of fidelity and its application to defining species groups. – J. Veg. Sci. 11: 167–178, Uppsala.
Chytrý, M. (2007) [Hrsg.]: Vegetation of the Czech Republic – 1. Grassland and Heathland Vegetation [tschech., engl. Zus.]. – 526 S., Academia, Praha.

- **Advantages (additional):**
  - Provides a clear and easy-to-understand "definition" of a syntaxon,

    Example:
    Plantagini maritimae-Caricetum flaccae (in Chytrý 2007):
    Def.: Carex flacca group AND Plantago maritima group
    Carex flacca group = Carex flacca, Carex tomentosa, Tetragonolobus maritimus
    Plantago maritima group = Carex distans, Centaurium pulchellum, Plantago maritima
  - Additionally, cover criteria can be used in the formal definition of syntaxa

(1) Statistical fidelity measures & species-group method

- **Disadvantages (additional):**
  - Many relevés remain unassigned (Chytrý 2007: 50-70%!)
  - Statistical fidelity measures such as u-value or phi-value strongly depend on the number of available relevés of each syntaxon:
    - classification changes, when additional relevés of a certain syntaxon are added
    - a species may be regarded as diagnostic in one syntaxon and not in another syntaxon, even if it is more frequent in the latter
  - So far there is no solution for hierarchical classification with the species-group method
  - Fidelity comparison with all relevés not belonging to a certain syntaxon and not with all equally-ranked other syntaxa separately

(2) Modifications of the species-group method

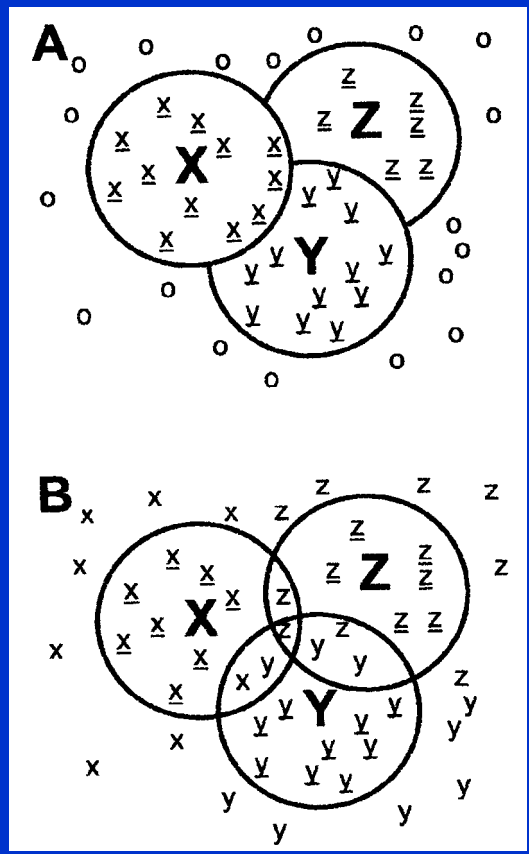
- **Standardisation of relevé numbers per syntaxon**

  Tichý, L., Chytrý, M. (2006): Statistical determination of diagnostic species for site groups of unequal size. – J. Veg. Sci. 17: 809–818, Uppsala.

- **Treatment of non-assigned or double-assigned relevés**
  - Post-hoc assignment with similarity indices

  Tichý, L. (2005): New similarity indices for the assignment of relevés to the vegetation units of an existing phytosociological classification. – Plant Ecol. 179: 67–72.

  Kočí, M., Chytrý, M., Tichý, L. (2003): Formalized reproduction of an expert-based phytosociolocical classification: A case study of subalpine tall-forb vegetation. – J. Veg. Sci. 14: 601–610, Uppsala.



(3) Validation of a classification

Illyés, E., Chytrý, M., Botta-Dukát, Z., Jandt, U., Škodová, I., Janišova, M., Willner, W., Hájek, O. (2007): Semi-dry grasslands along a climatic gradient across Central Europe: Vegetation classification with validation. – J. Veg. Sci. 18: 835–846, Uppsala.

- **Idea**
  - Numerical classifications (cluster analyses) are highly idiosyncratic, i.e. they may extremely differ when the dataset is only slightly altered
  - Whole dataset is subdivided in two datasets TRAINING and TEST and only those clusters are accepted as valid that are differentiated in both partial datasets
- **Problems**
  - The “non-valid” clusters similarly represent real vegetation and thus should not be disregarded
  - With only two subsets of data, the decision about the cluster validity itself is highly arbitrary

(4) Approach of Dengler

Dengler, J. (2003): Entwicklung und Bewertung neuer Ansätze in der Pflanzensoziologie unter besonderer Berücksichtigung der Vegetationsklassifikation. – Arch. Naturwiss. Diss. 14: 297 S., Galunder, Nümbrecht.
Dengler, J., Berg, C., Jansen, F. (2005): New ideas for modern phytosociological monographs. – Ann. Bot. N. S. 5: 193–210, Rome.
Berg, C., Dengler, J., Abdank, A., Isermann, M. (2004) [Hrsg.]: Die Pflanzengesellschaften Mecklenburg-Vorpommerns und ihre Gefährdung – Textband. – 606 S., Weissdorn, Jena.

- **Idea**
  - Axiomatic version of the Braun-Blanquet approach
  - Clear rules for diagnostic species and for syntaxa
- **Advantages**
  - Allows hierarchical classification
  - Can be applied both in manual table sorting and in numerical classification

(4) Approach of Dengler

- **Disadvantages**
  - So far no “computerized” version of this approach has been programmed
  - So far no “statistical” fidelity measures have been implemented

Outlook

- Many promissing approaches and many data available
- However, additional developments are still necessary to produce sound large-scale classifications on the basis of large vegetation databases
- In the dry grassland working groups, we have the potential to contribute to that necessary pioneering work

Many thanks to

- the active members of the AG Trockenrasen and the Working Group on Dry Grasslands in the Nordic and Baltic Region

and

- You for your attention!