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Restoring wet grasslands by mowing and diaspore transfer with hay

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Limiting factors in wet grassland restoration

Abiotic constraints:

e.g. nutrient status, pH, hydrology

Biotic constraints:

- depleted seed bank of restoration sites
- limited dispersal in fragmented landscapes
- lack of regeneration niches (micro-site limitation)

Poor results

even under favourable abiotic and management conditions

Lowering of productivity

Depletion of nutrients by:

- **Haymaking**
- **Topsoil removal**

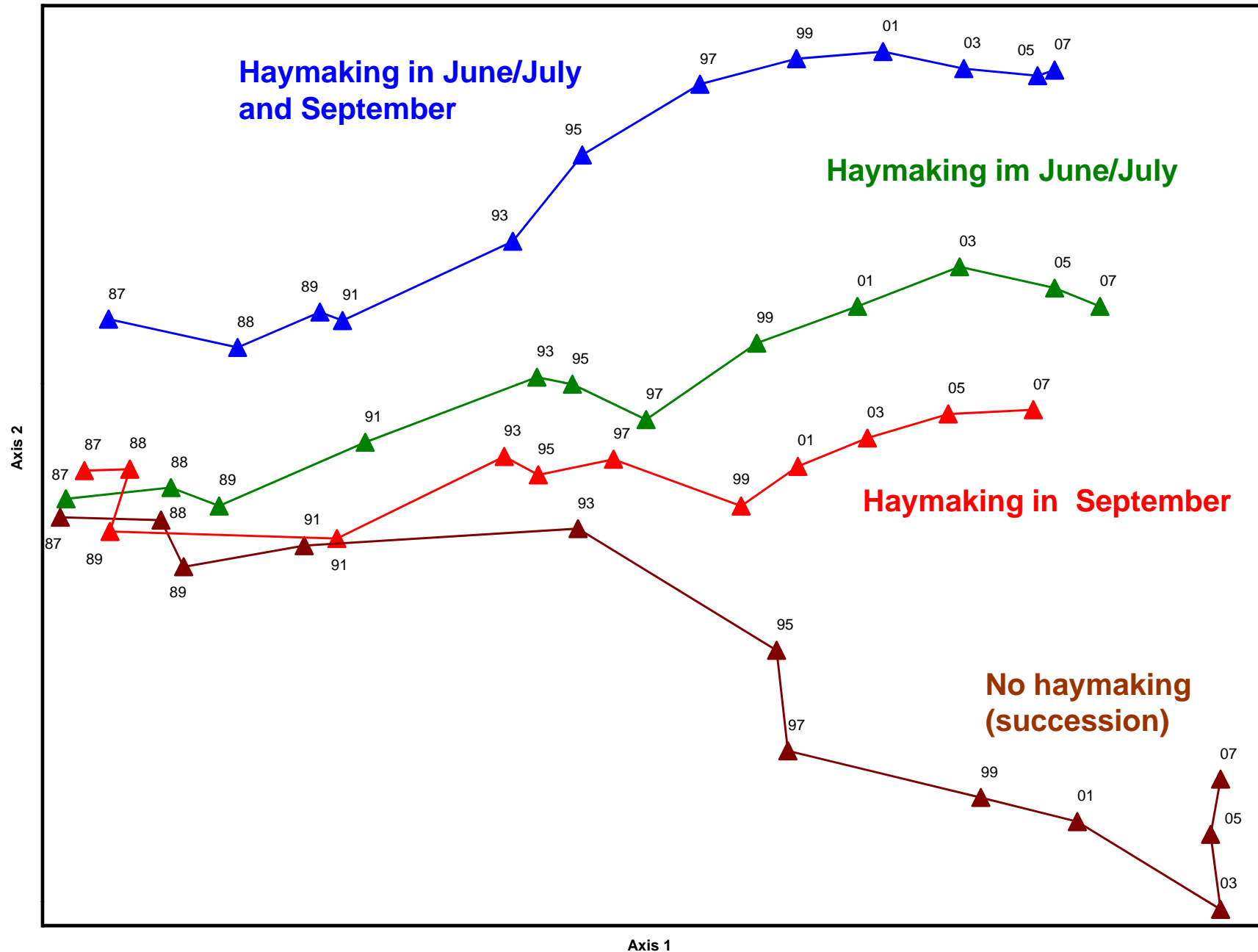
Nutrient impoverishment by haymaking in wet meadows on sandy and organic soils



Peter Schwartz



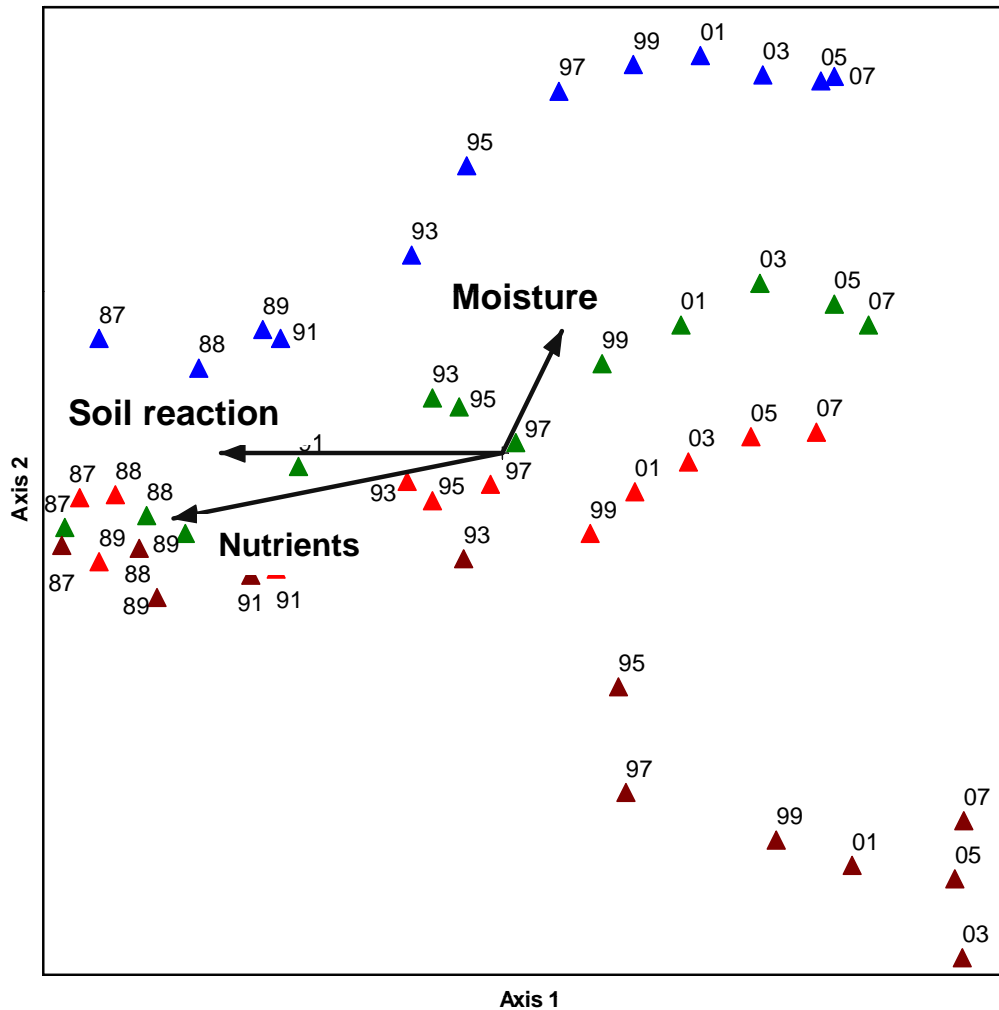
Effects of restoration management in wet meadows



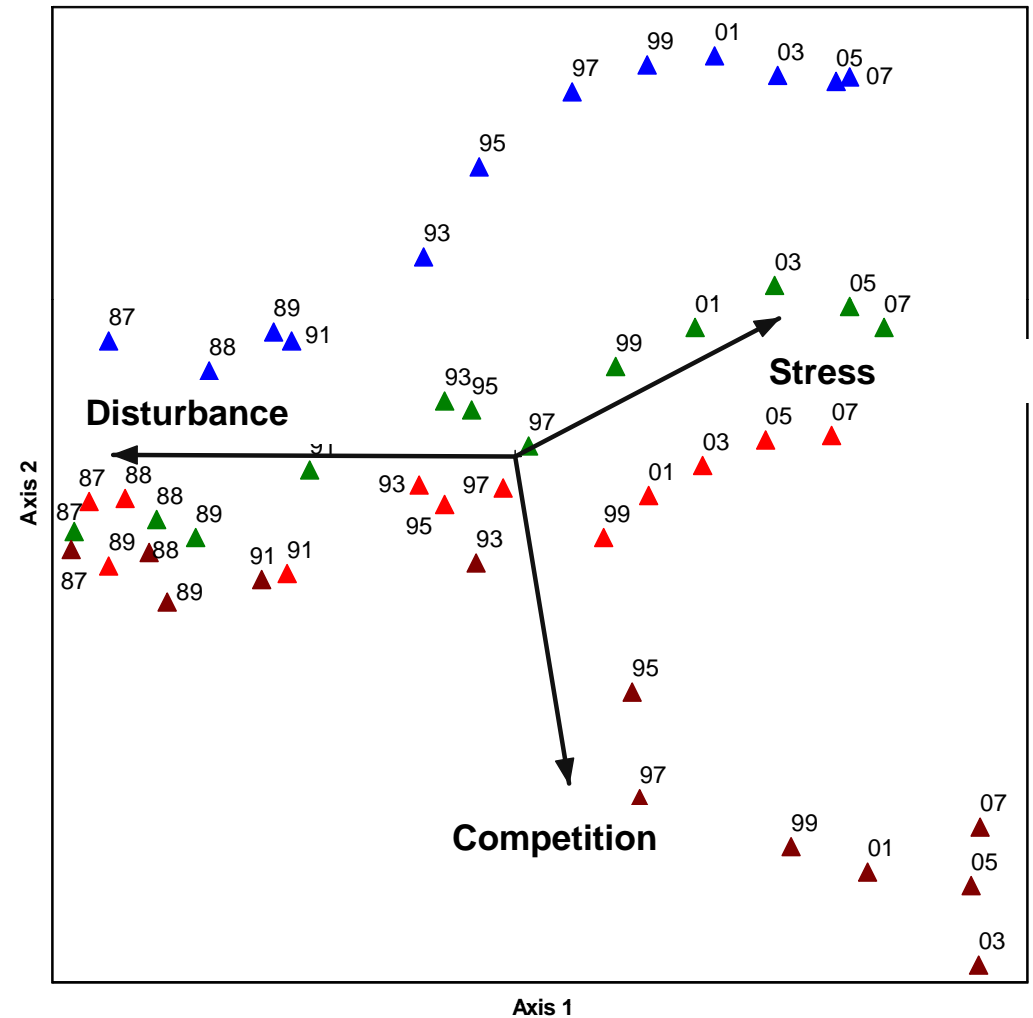
Poptcheva, K., Schwartze, P., Vogel, A., Kleinebecker, T. & Hölzel, N. (2009) Changes in wet meadow vegetation after 20 years of different management in a field experiment (North-West Germany). *Agriculture, Ecosystems and Environment* (doi:10.1016/j.agee.2009.06.004)

Post hoc interpretation of ordination results

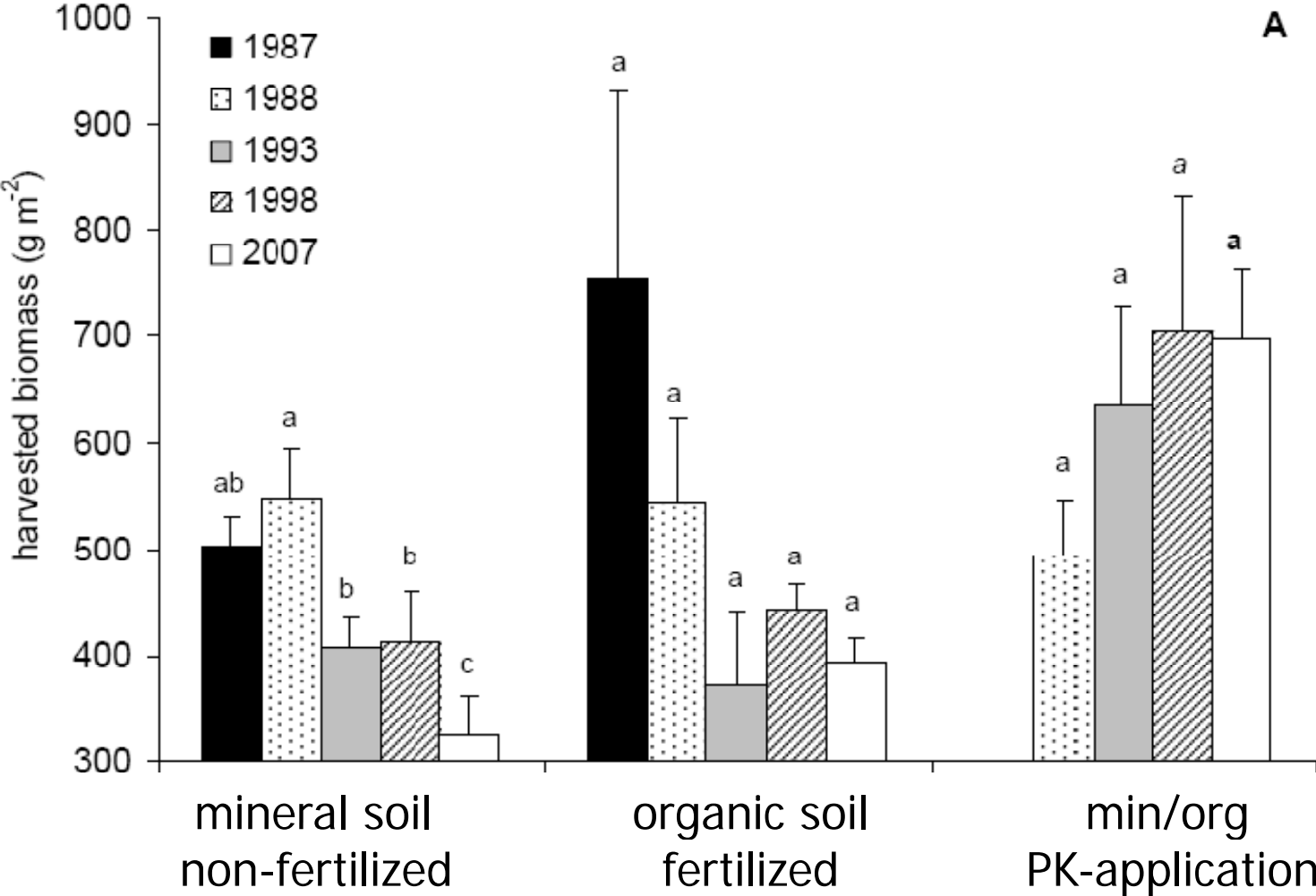
Ellenberg values



C-S-R Strategy Types by Grime

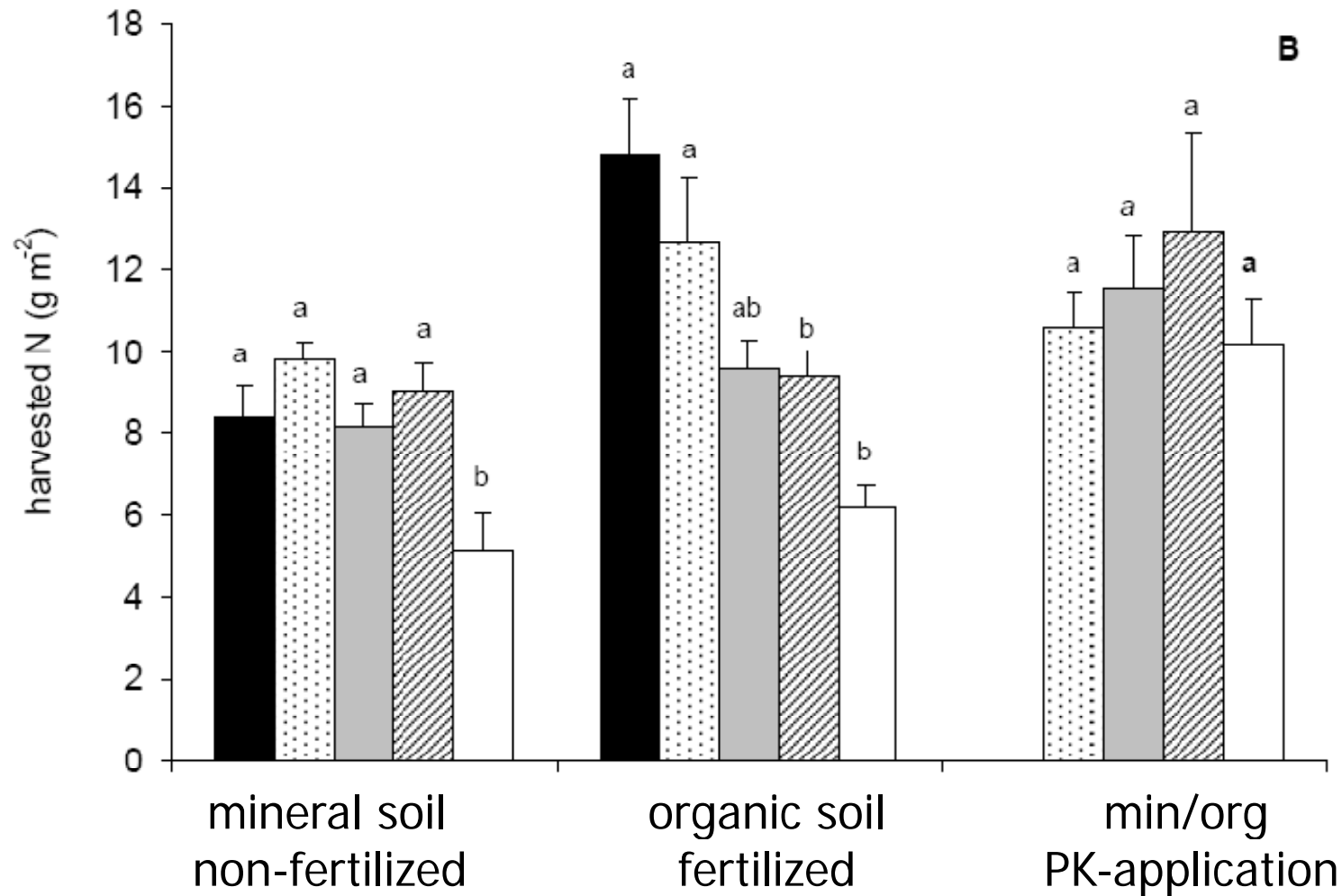


Change in harvested biomass (mowing twice a year)



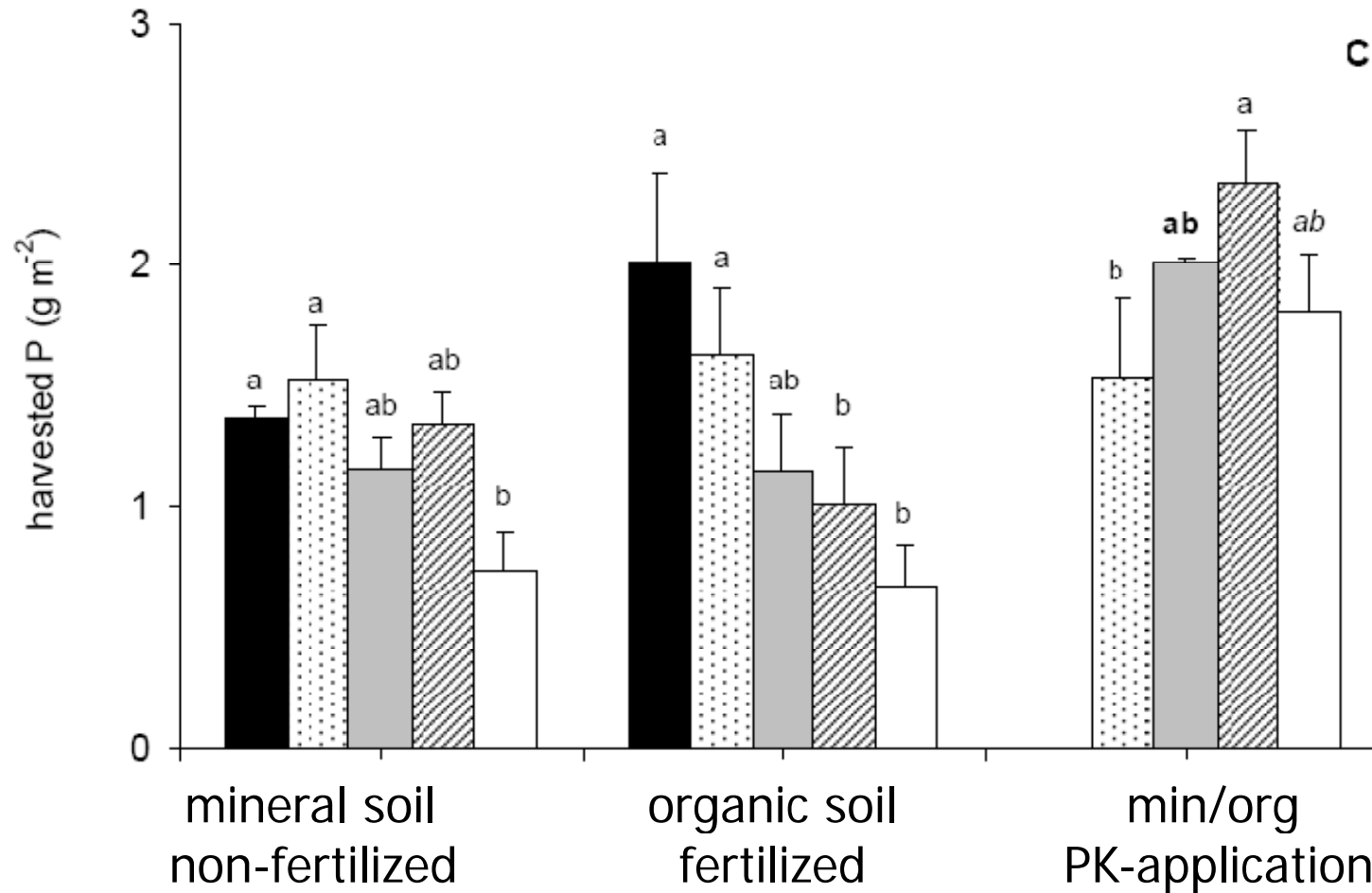
Oelmann, Y., Broll, G., Hölzel, N., Kleinebecker, T., Vogel, A. & Schwartz, P. (submitted) Nutrient impoverishment and limitation of productivity after 20 years of conservation management in wet grasslands of north-western Germany. *Biological Conservation*

Change in harvested N (mowing twice a year)



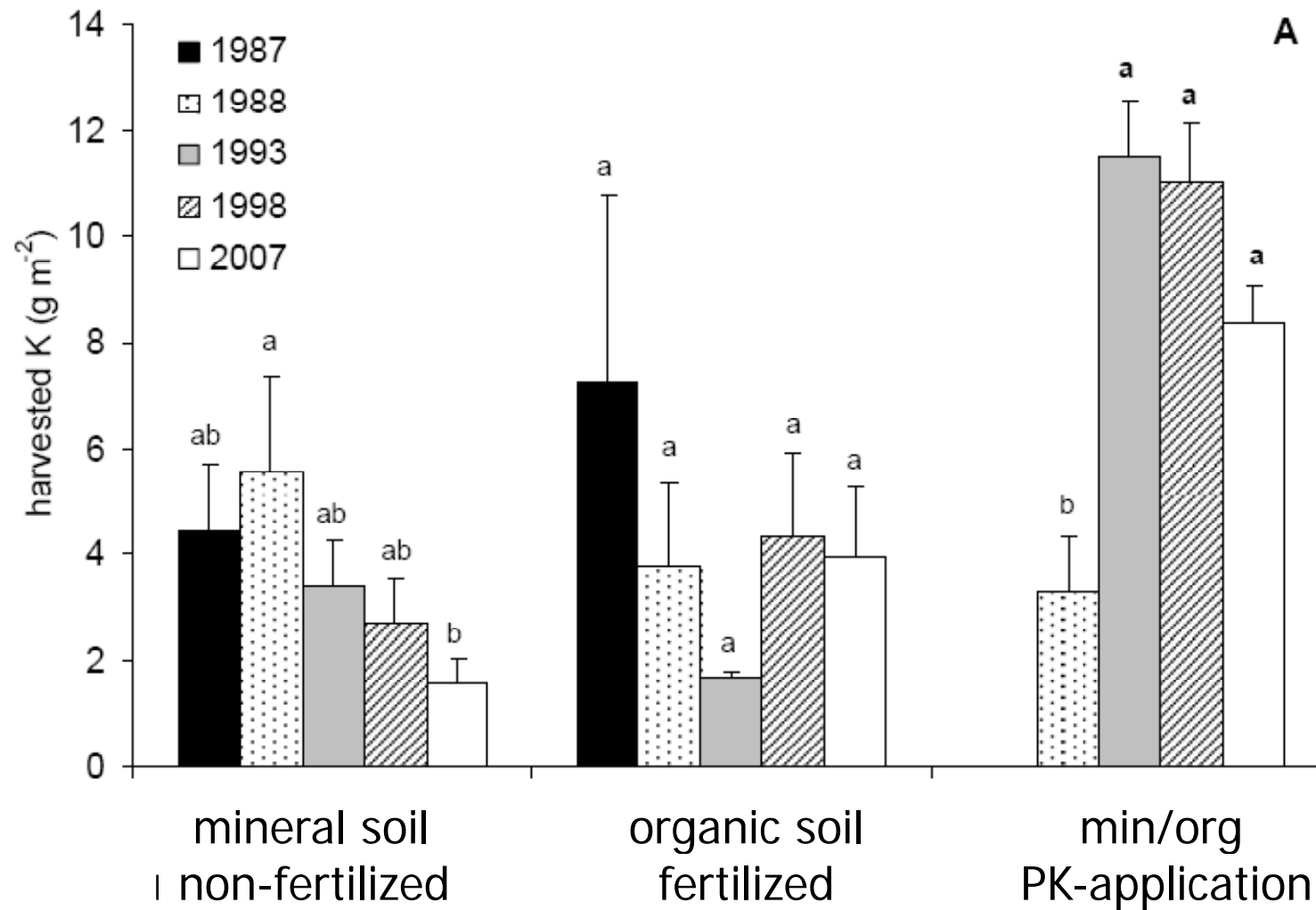
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Change in harvested P (mowing twice a year)



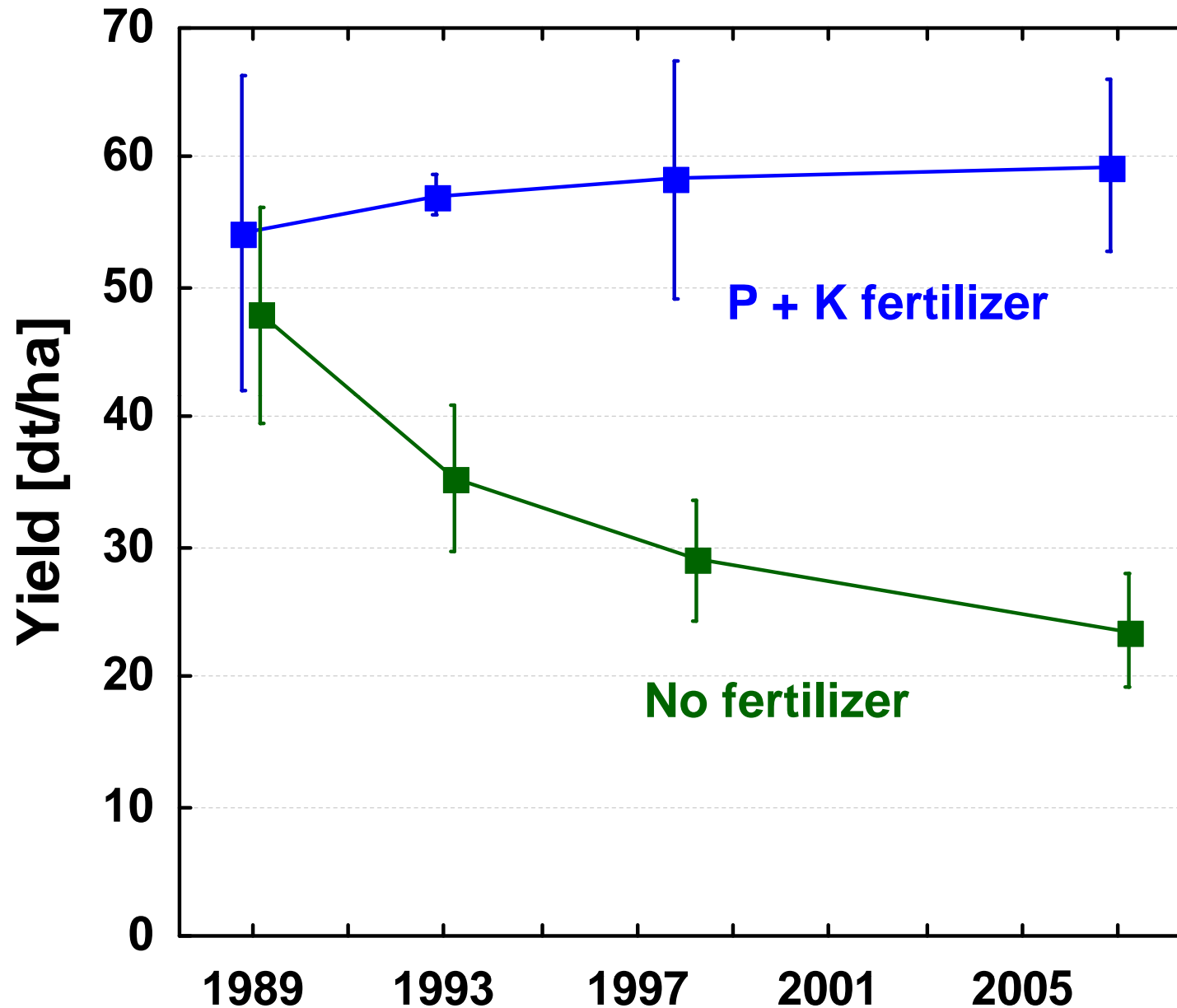
Oelmann, Y., Broll, G., Hölzel, N., Kleinebecker, T., Vogel, A. & Schwartz, P. (submitted) Nutrient impoverishment and limitation of productivity after 20 years of conservation management in wet grasslands of north-western Germany. *Biological Conservation*

Change in harvested K (mowing twice a year)



Oelmann, Y., Broll, G., Hölzel, N., Kleinebecker, T., Vogel, A. & Schwartz, P. (submitted) Nutrient impoverishment and limitation of productivity after 20 years of conservation management in wet grasslands of north-western Germany. *Biological Conservation*

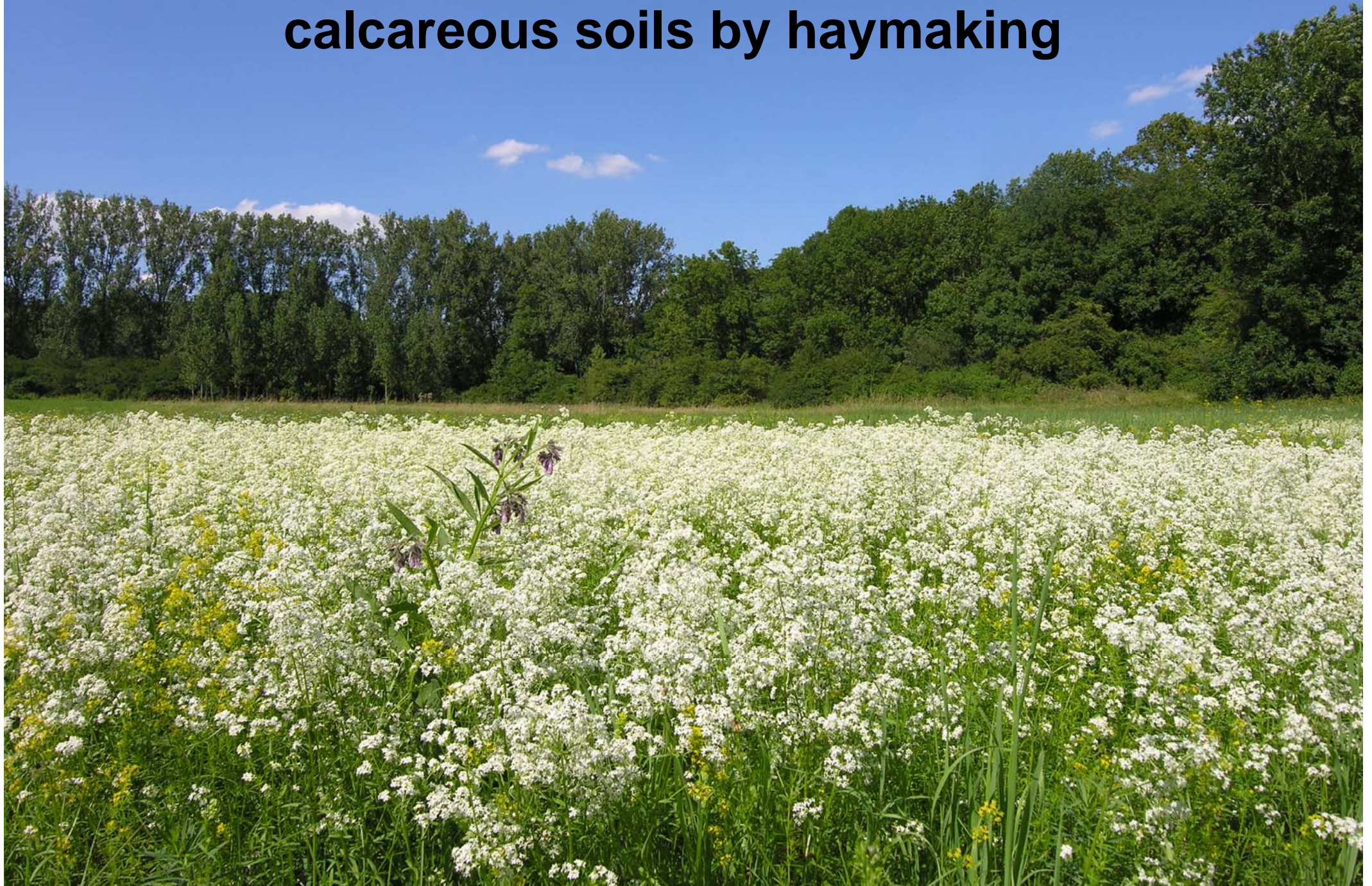
Yield in wet meadows over 20 years of haymaking



Restoration by hay-making (sandy & organic soils)

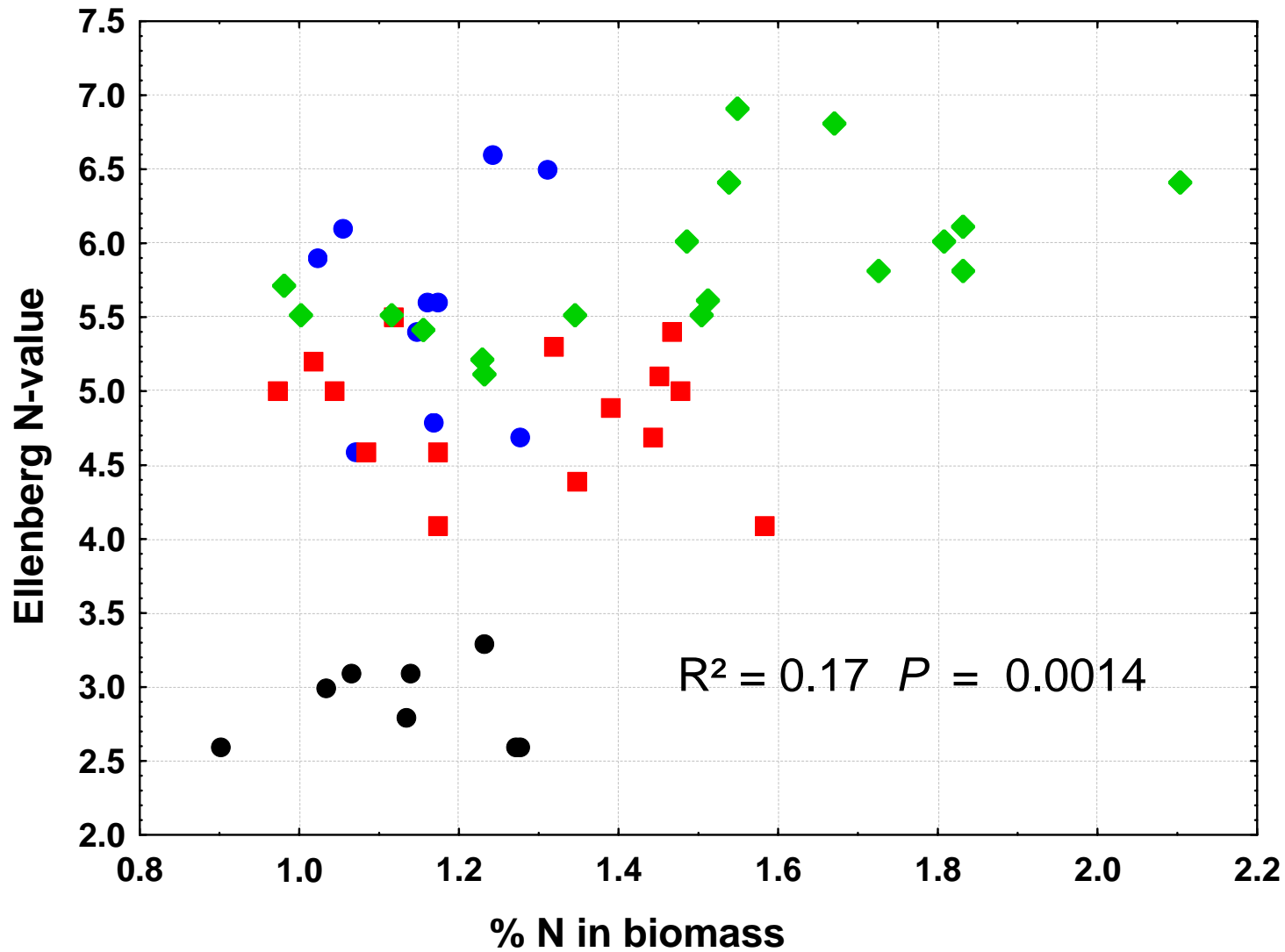
- **rapid decline of productivity despite high N-deposition**
- **P und K limit productivity!**
- **decline of ruderals and nutrient demanding species**
- **increase of stress-tolerant species (sedges & rushes)**
- **minor increase in species-richness**
- **very slow immigration of new target species**

Restoration of flood-meadows on loamy calcareous soils by haymaking



N in standing crop

n = 51

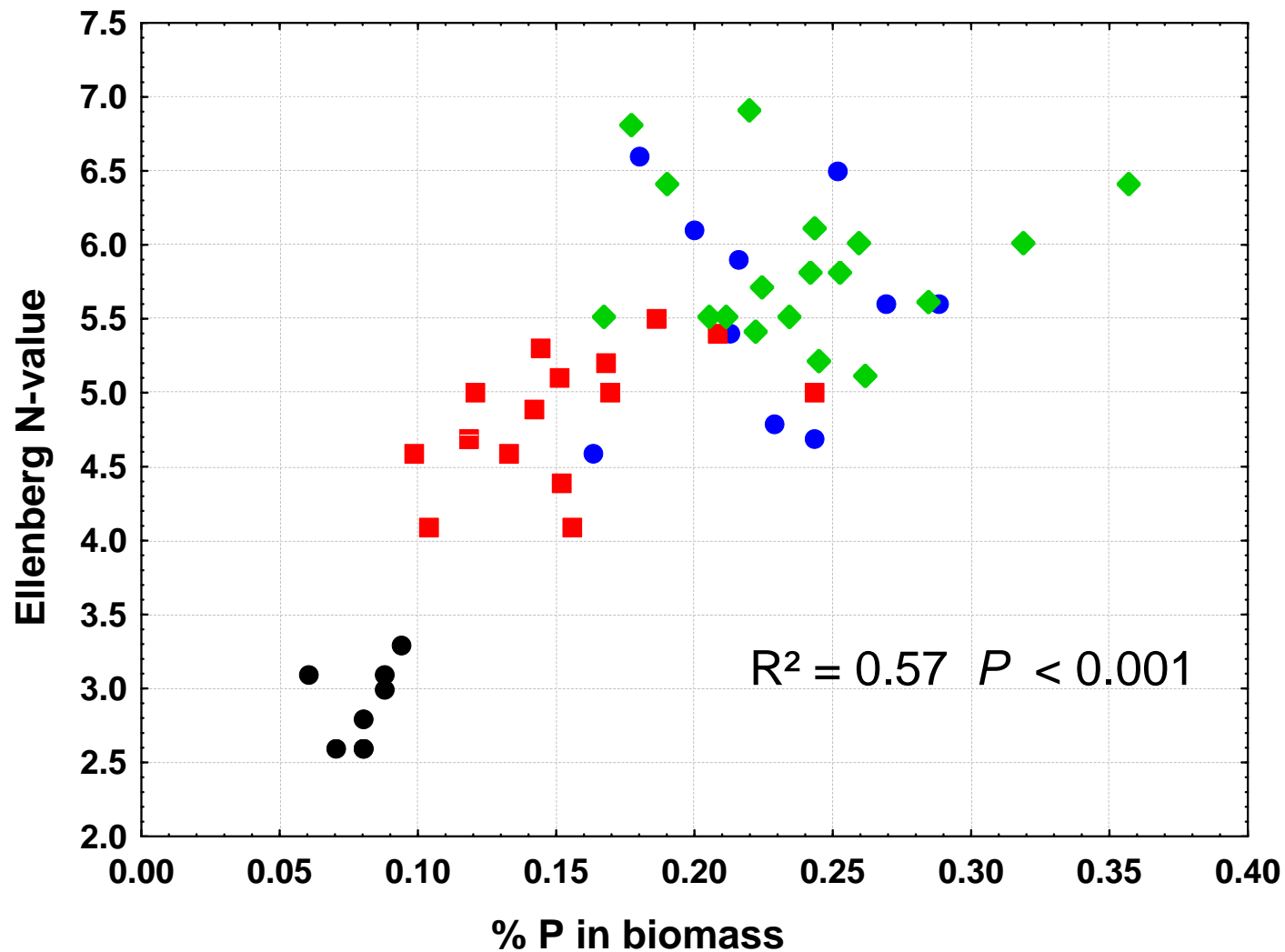


Hölzel *et al*
submitted

- Molinion
- Cnidion (unintensive)
- Ex-arable
- ◆ Cnidion (fertilised)

P in standing crop

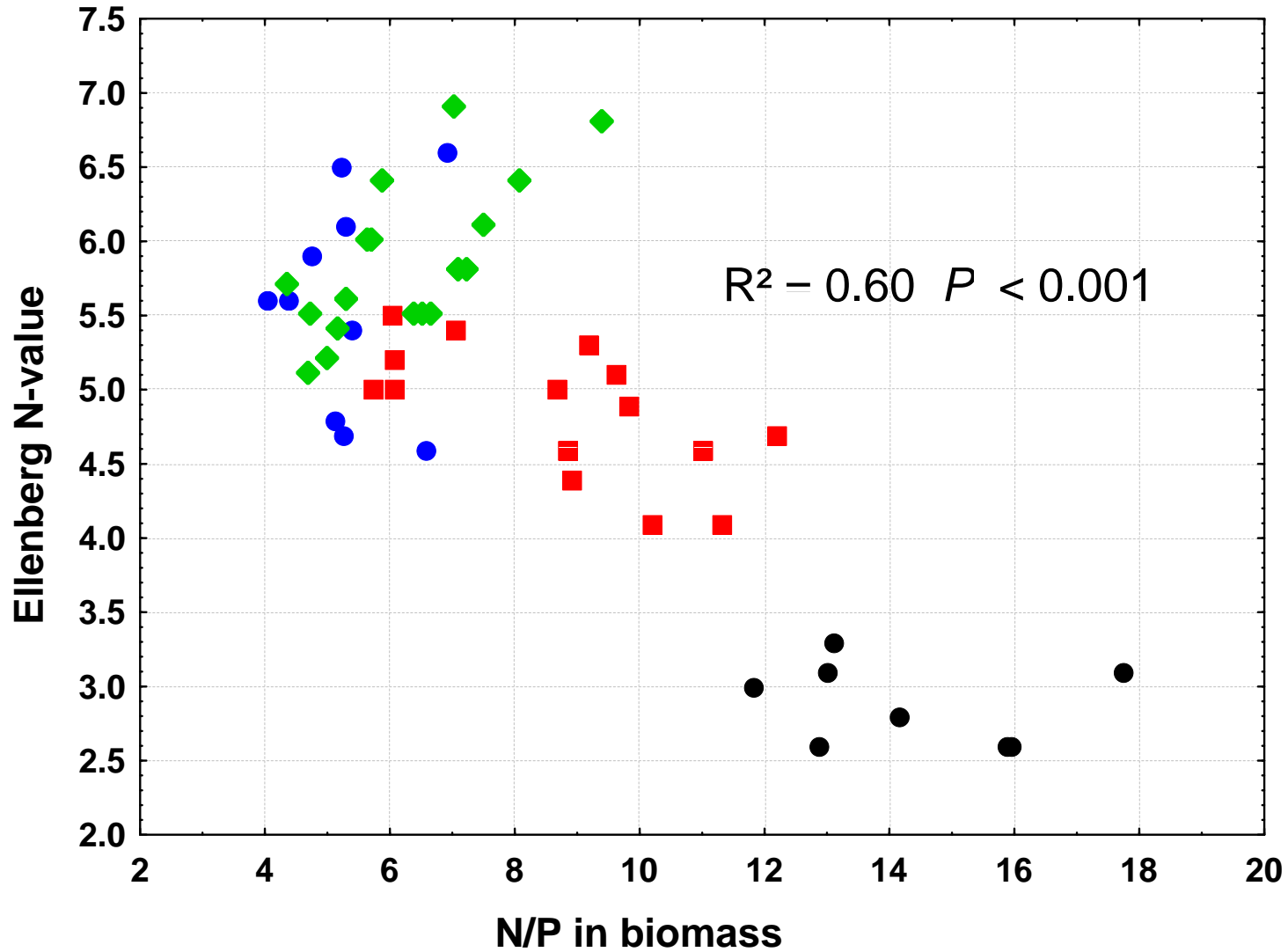
n = 51



- Molinion
- Ex-arable
- Cnidion (un-intensive)
- ◆ Cnidion (fertilised)

N/P-ratio in standing crop

n = 51

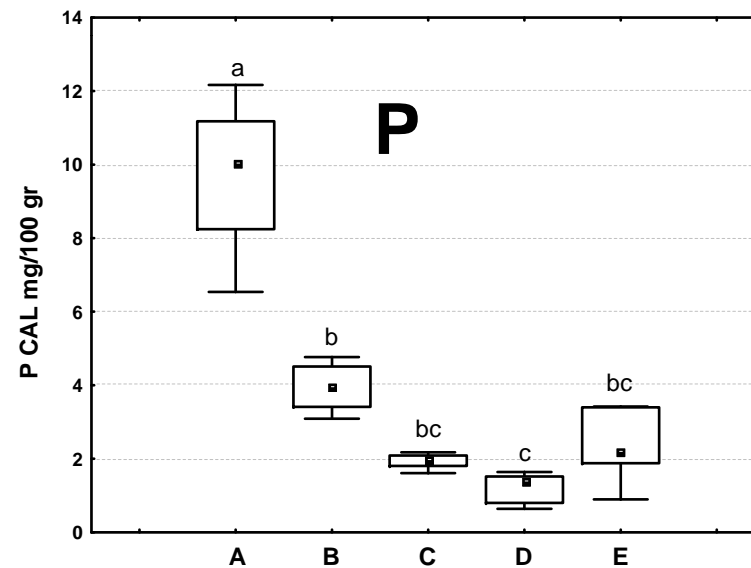
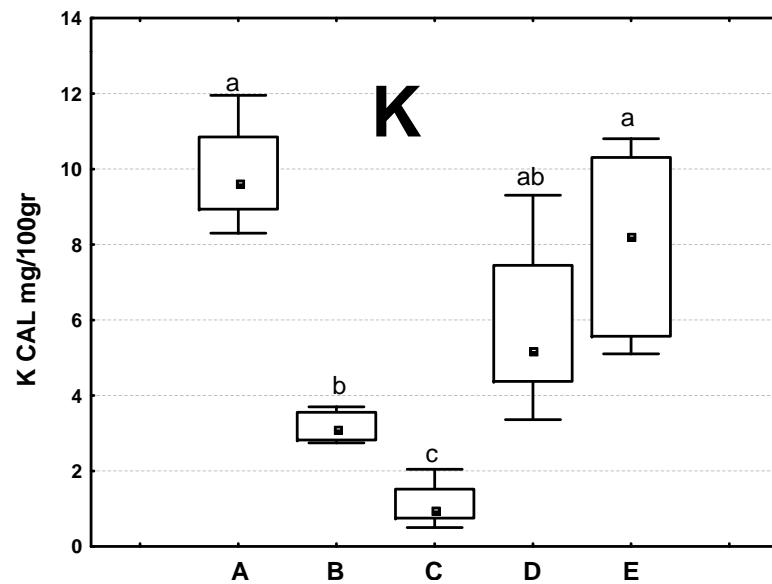
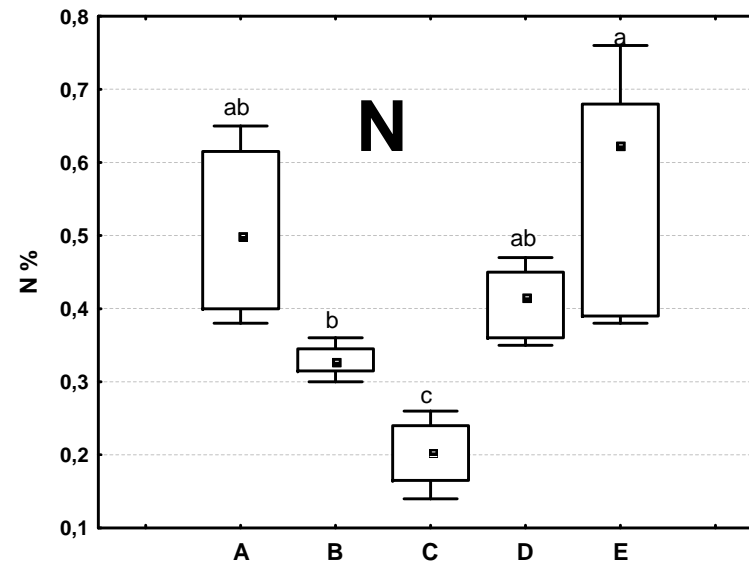
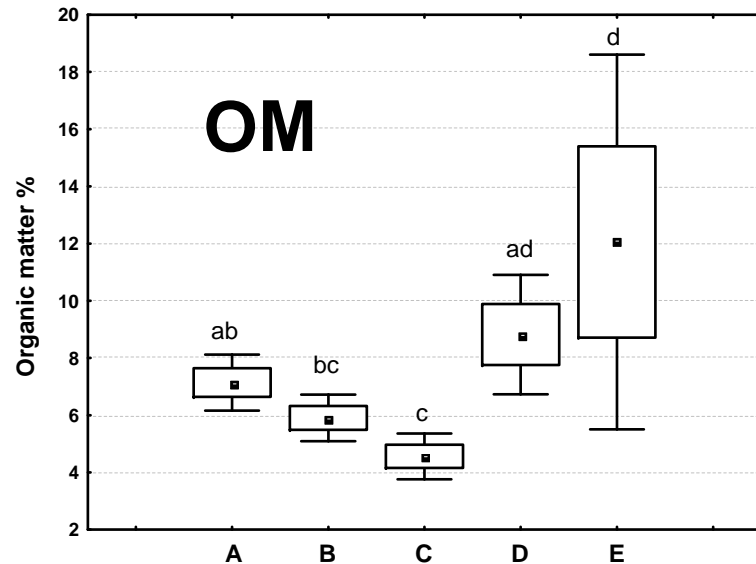


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Topsoil removal





A = Original arable field
 B = 30 cm topsoil removal
 C = 50 cm topsoil removal

D = Molinion-source stands
 E = Cnidion-source stands

Lowering productivity on loamy soils:

- **relatively fast N-limitation in ex-arable fields**
- **raised P-levels even after long-term nutrient depletion**
- **rapid reduction P-residuals only by topsoil removal**
- **effects of raised P-levels under N-limitation still unclear**

Depleted seed and bud banks

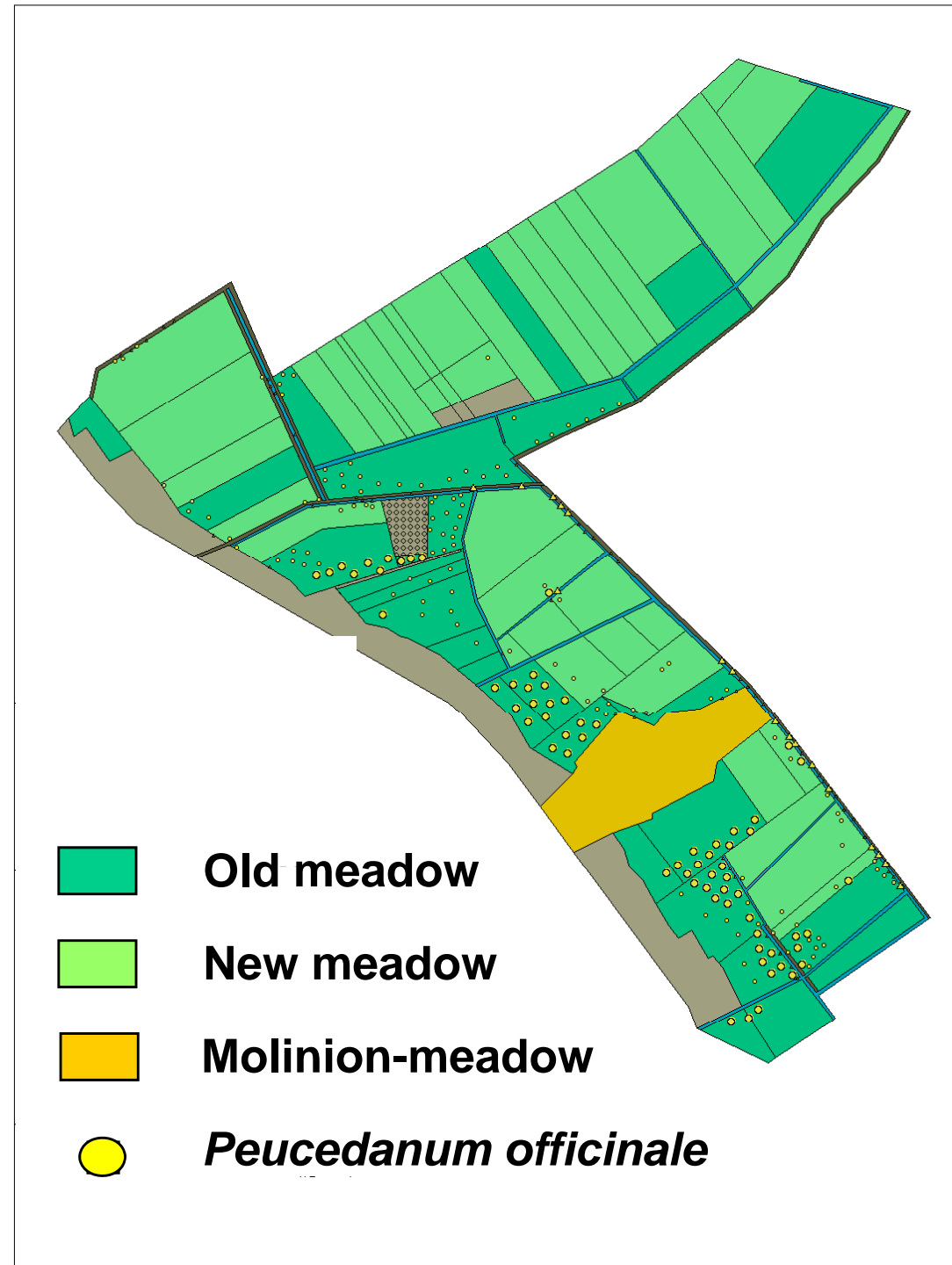
- **limited proportion of target species with long-term persistent seed banks**
- **rapid depletion of persistent seed and bud banks after arable cultivation and extended periods of intensive grassland management**
- **significant contribution to restoration is confined to**
 - **sites with short history of use-intensification**
 - **fallows after re-introduction of management**

Limited seed dispersal

- **low capacity in many target species for seed dispersal over larger distances or mainly vegetative spread**
- **lack of viable source populations in close proximity to restoration sites due to habitat fragmentation**
- **loss of traditional agricultural dispersal vectors such as**
 - **haymaking**
 - **aftermath pasture with moving livestock**
 - **spreading of solid manure from cattle fed with hay**
 - **sowing of hay residuals**
- **generally low invasibility of closed swards**



Donath, T.W., Hölzel, N. & Otte, A. (2003):
The impact of site conditions and seed
dispersal on restoration success in alluvial
meadows.
Applied Vegetation Science 6: 13-22.

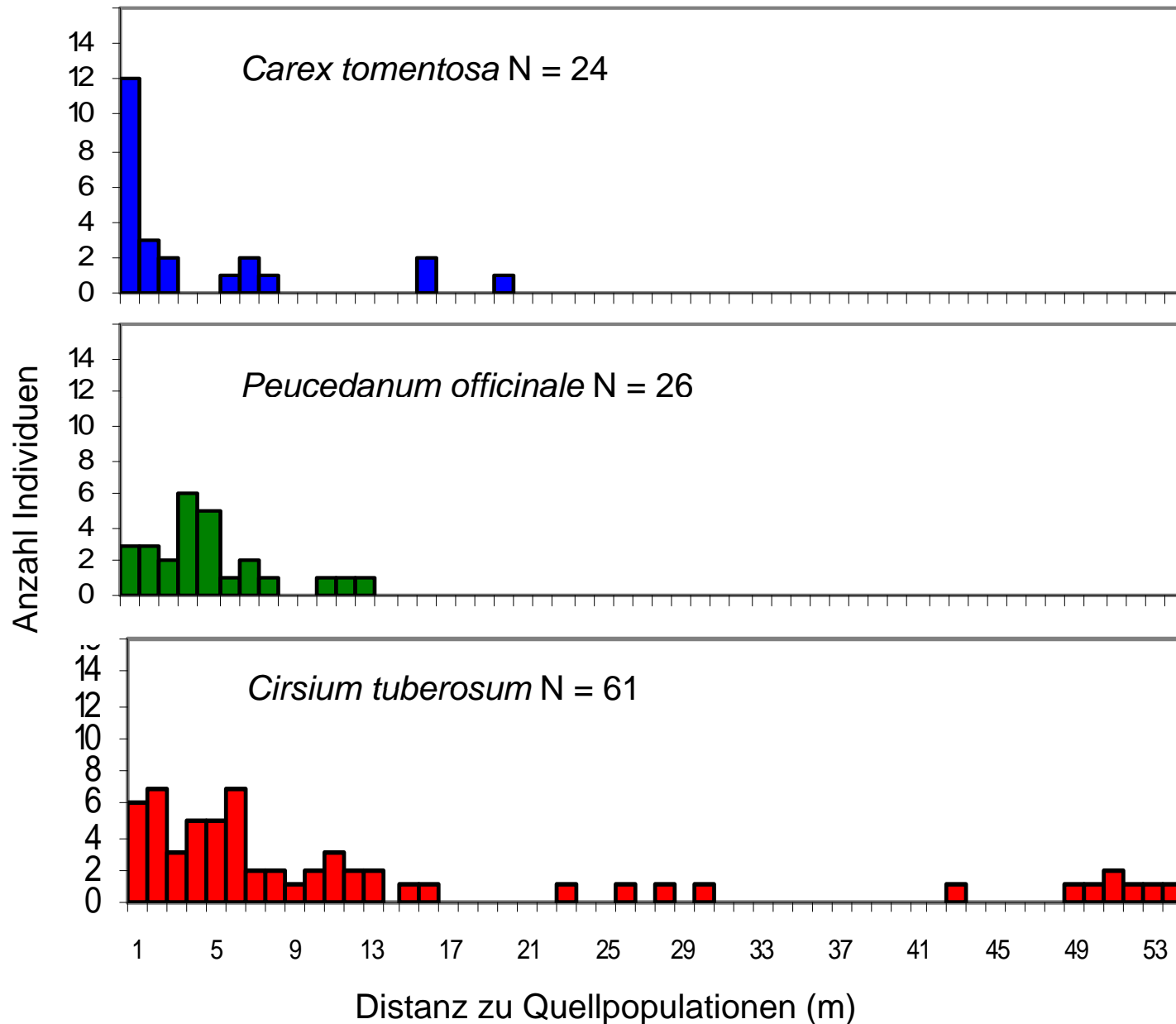




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Dispersal distance of target species after ca. 10 years



Transfer of species to restoration sites



Source stand (species-rich *Cnidion* meadow)



Harvesting of species-rich source stands



Transfer of seed-containing plant material



After transfer 1997

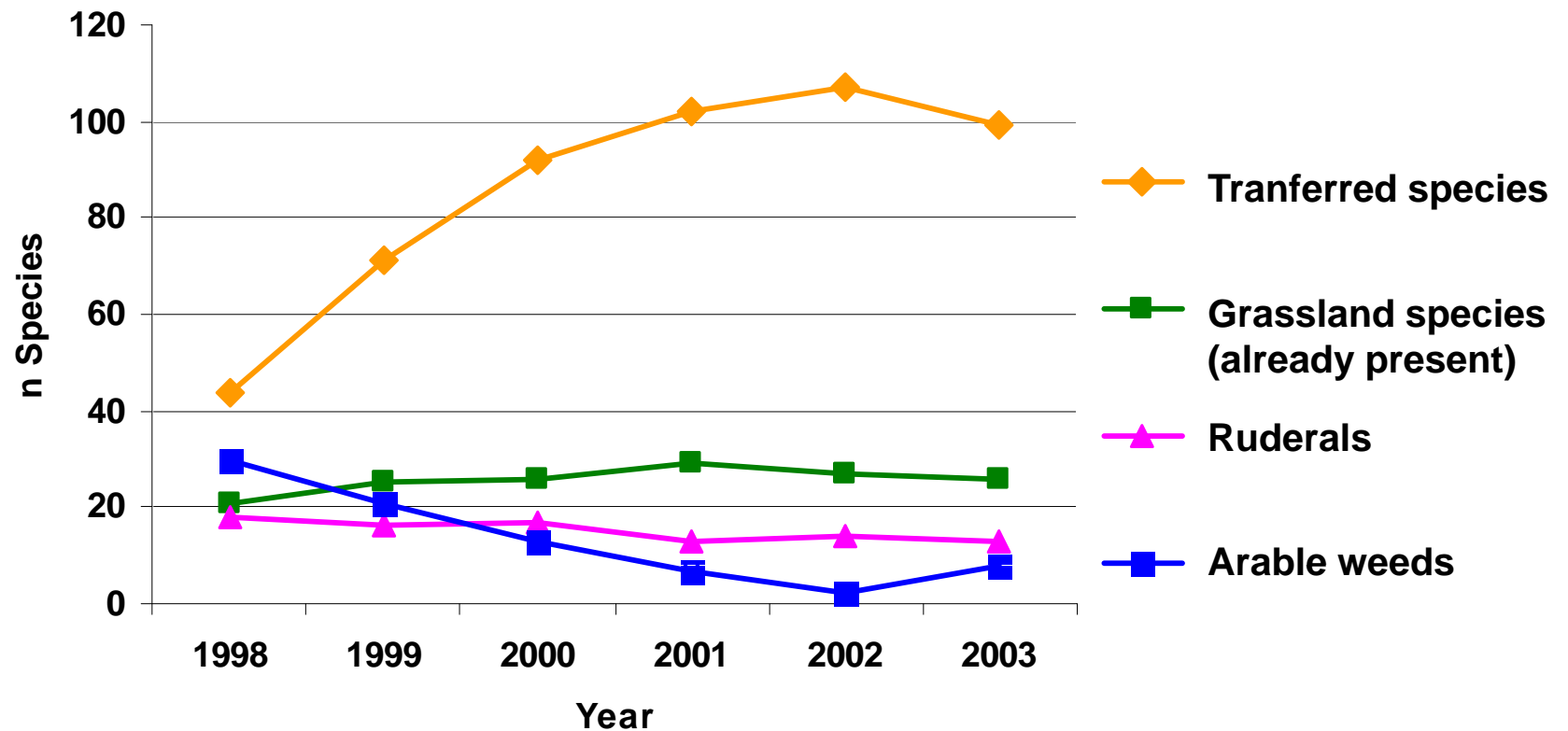


7 years after tranfer



Development of different species groups after transfer of seed-containing plant material

n = 80 plots



Transferred target species:



Gentiana pneumonanthe



Arabis nemorensis



Viola elatior



Iris spuria

Former arable fields



Spreading of seed-containing plant material



Diaspore transfer with hay bales



Disturbance of closed swards



Spreading of seed-containing plant material (grassland)



Strips with plant material



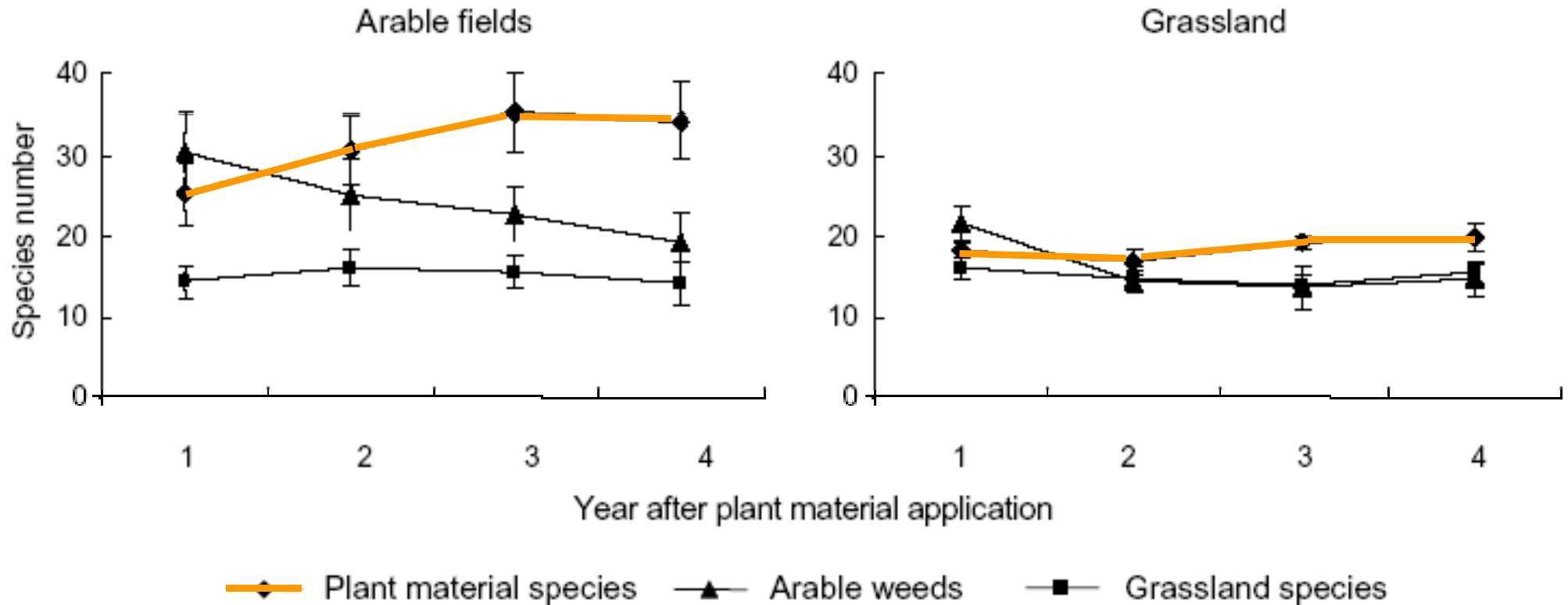
Weed aspect 1 year after seed transfer



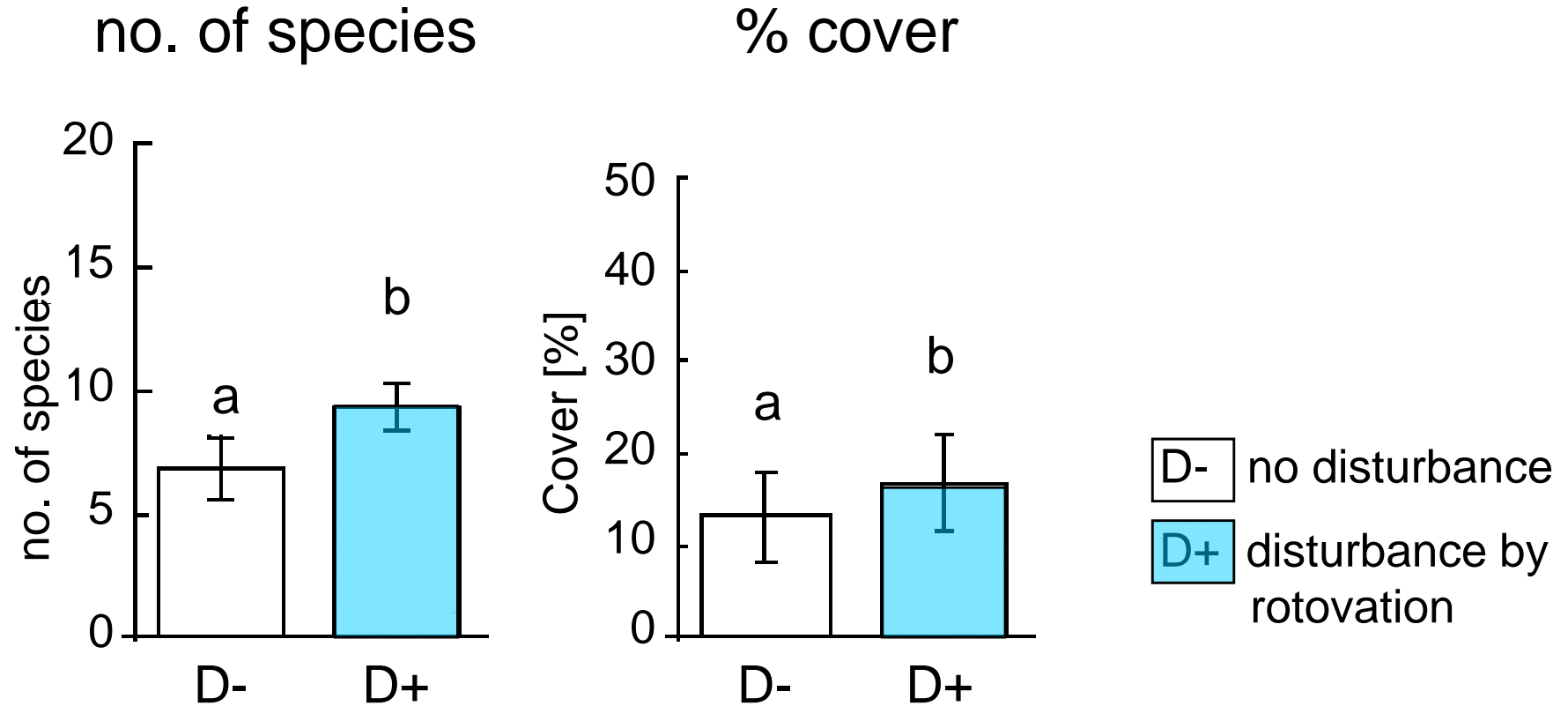
Meadow aspect 4 years after seed transfer



Establishment success in ex-arable fields and grasslands



Sward disturbance facilitates recruitment in grasslands



Going home messages

- **without species introduction restoration measures are often frustratingly unsuccessful!**
- **species transfer is the only way to overcome dispersal limitation in fragmented landscapes!**
- **restoration of species-rich communities by the spreading of plant, raking and topsoil material from species-rich source stands is mostly very successful!**
- **trajectories of vegetation succession are determined by environmental filters (moisture, nutrient availability)**

Preconditions

- **suitable abiotic site conditions**
- **high quality of transferred plant, raking or soil material in terms of seed density and species composition**
- **low competition by established vegetation in early stages of succession**
- **heavy disturbances or even removal of the topsoil can be essential**
- **adequate management is crucial for the maintenance of newly restored species-rich communities**

A landscape photograph showing a field of tall green grass with numerous small yellow flowers. In the background, a large, leafy tree stands on the left side under a clear blue sky. The text is overlaid on the upper portion of the image.

Thanks to:

Stephanie Bissels, Gabi Broll, Tobias Donath, Matthias Harnisch,
Till Kleinebecker, Yvonne Oelmann, Annette Otte,
Kathrin Poptcheva, Peter Schwartz, Andreas Vogel

**Thank you
for your attention!**