COS 114 - Biogeochemistry: Linking Community Structure and Ecosystem Function

Soil pH, ecological stoichiometry, and allometric scaling in soil biota

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ALBUQUERQUE

Biological Indicator for Soil Quality

- BISQ is based on

  A broad definition of biodiversity: all biota, ecosystems and functions

  (ratification by Dutch Government and granted to RIVM)

- BISQ aims to

  Develop quality standards for soil organisms outside nature area's to protect ecological function and services of the soil

- Our assessment relies upon

  500 locations in The Netherlands

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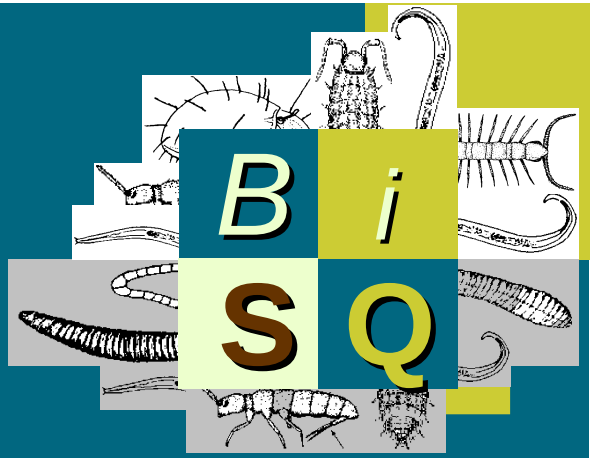
Goal of this lecture



- Get more insights on the influence of nutrient supply and land management on trophic interactions and biota
- Comparison of effects of the two energy channels on the community structure of detrital soil food webs:

  Bacterial-based energy channel (***high*** **nutrient supply rates**, low carbon sequestration, high litter quality)

  Fungal-based energy channel (***low*** **nutrient supply rates**, high carbon sequestration, low litter quality)

Collecting size, mass and abundance is expensive …

Nr	Taxon	M/V/J[1])	Kop[2])	Gewicht	lengte	Aantal	breedte
1	Eucephalobus oxyuroides	♀		559,44		22,72	
2	Aphelenchoides	j		468,72		11,34	
3	Eucephalobus oxyuroides	♂		594,72		25,2	
4	Panagrolaimus	j		280,52		15,12	
5	Plectus	j		458,64		12,61	
6	Aphelenchoides	j		660,24		13,86	
7	Tylenchidae	j		403,2		10,08	
8	Eucephalobus	j		254,52		12,6	
9	Plectus	j		1504,44		25,92	
10	Pratylenchus penetrans	♀		509,04		12,64	
11	Aglenchus agricola	♂		544,32		15,12	
12	Aglenchus agricola	♀		551,88		20,16	
13	Tylenchidae	j		493,92		13,6	
14	Helicotylenchus pseudorobustus	♀		693,0		20,2	
15	Paratylenchus	j		216,72		11,34	
16	Tylenchidae	j		315,0		12,6	
17	Tylenchidae	j		554,4		17,64	
18	Eucephalobus	j		428,4		20,16	
19	Rhabditidae	j		408,24		20,16	
20	Aphelenchoides	j		345,24		12,6	
21	Malenchus andrassyi	♀		302,4		15,12	
22	Cephalobidae	j		332,64		15,12	
23	Acrobeloides	j	B	342,72		18,9	
24	Aglenchus agricola	♀		594,72		22,68	
25	Dolichodoridae	j		320,04		15,12	

*) M=mannetje, V=vrouwtje, J=juveniel.

Ingevoerd door :

Taxocenes	EURO
Bacteria	2230
Fungi	1033
Nematoda	269
Arthropoda	1438
Oligochaeta	1540
Abiotics	1693

8200 EURO

10,000 USD

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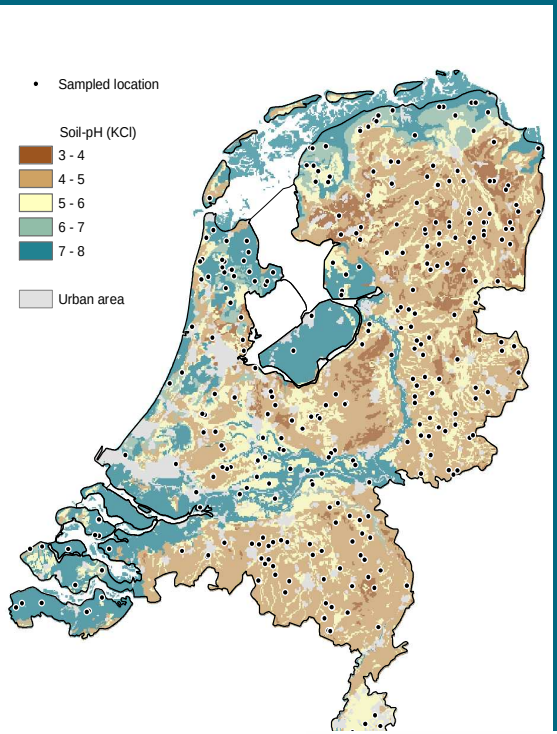
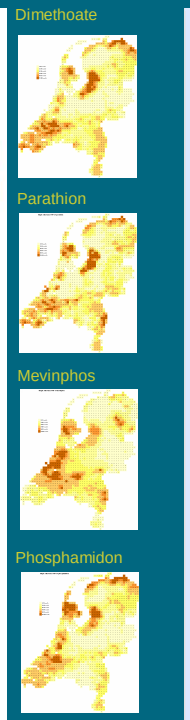
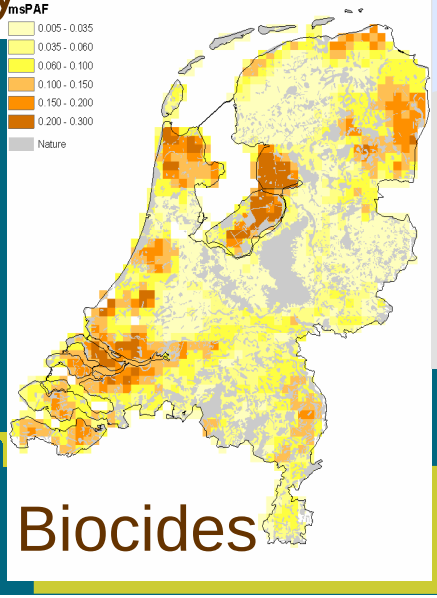
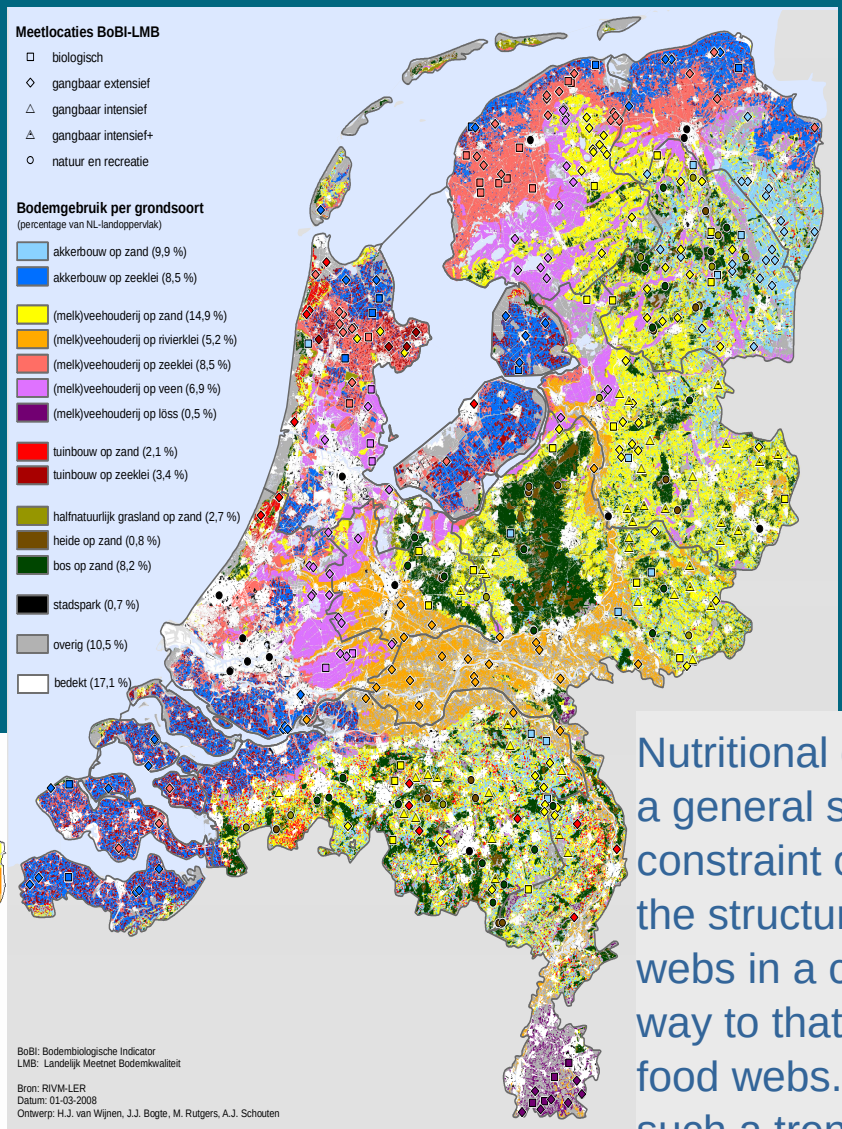


Soil acidity





Biocides



Nutritional quality acts as a general stoichiometric constraint on variation in the structure of soil food webs in a comparable way to that of aquatic food webs. How does such a trend hold for entirely different biota?

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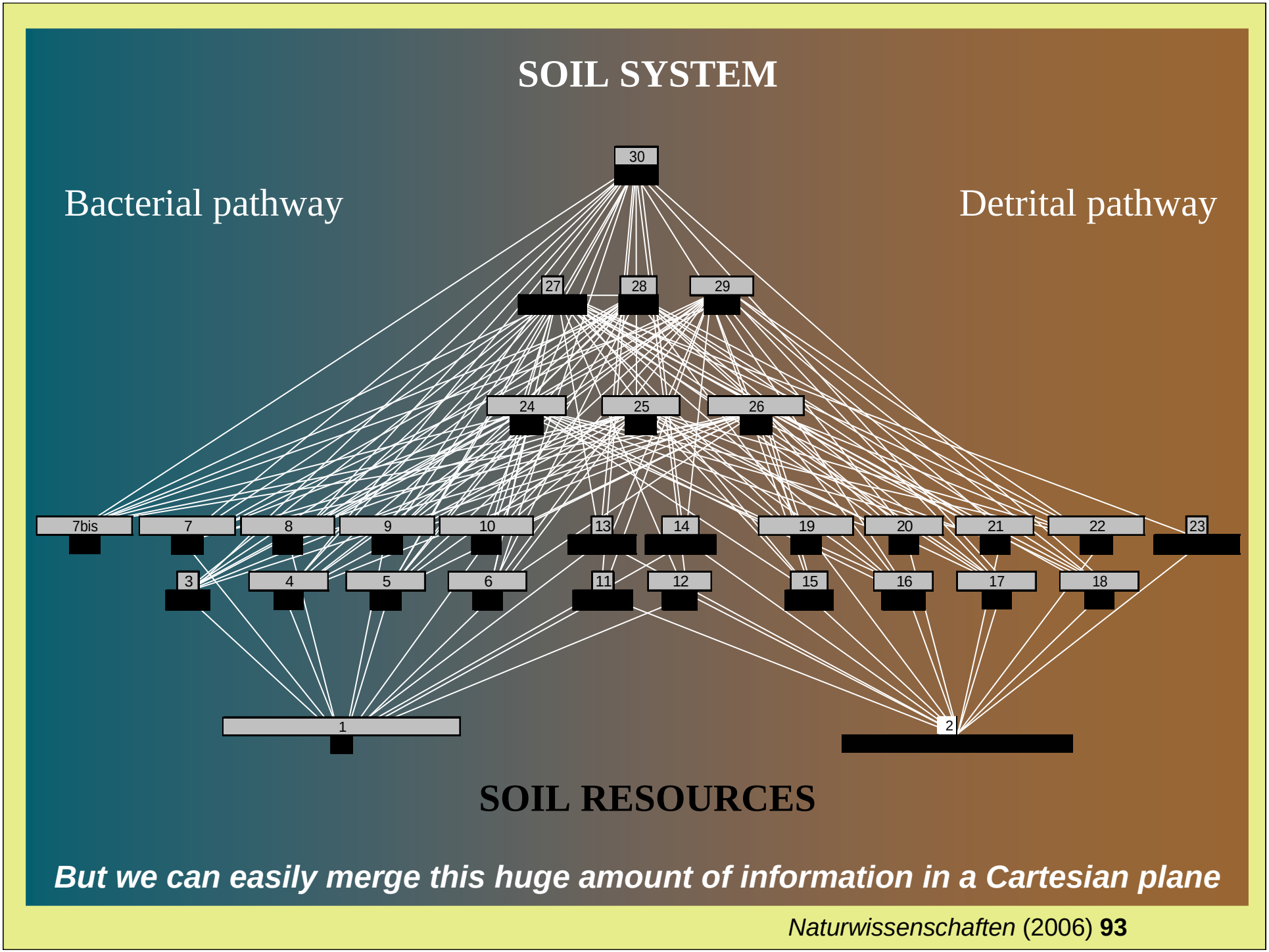
Publicly available data [Open Access]

N CONV	N INT	N ORG	M	-8.85 27	-8.81 28	-8.79 29	-8.42 30	-8.05 31	-7.77 32	-6.80 33	-6.80 34	-5.97 35	-5.05 36	-5.01 37	-4.82 38	-3.70 39
			0	0	1	0	0	0	1	1	1	1	0	1	1	1
11.95	10.75	12.39	1	1	1	0	0	0	1	0	0	1	0	1	1	0
2.55	2.80	2.99	2	0	0	1	0	1	0	0	0	0	1	0	0	0
3.15			3	0	0	1	0	1	0	0	0	0	1	0	0	0
	2.80	2.99	4	0	0	1	0	1	0	0	0	0	1	0	0	0
2.55		2.81	5	0	0	1	0	1	0	0	0	0	1	0	0	0
	2.97	3.42	6	0	0	1	0	1	0	0	0	0	1	0	0	0
4.04	3.91	3.85	7	0	0	1	0	1	0	0	0	0	1	0	0	0
3.24	2.80	2.99	8	0	0	1	0	1	0	0	0	0	1	0	0	0
3.75	3.67	3.69														
		2.51														
2.85	2.80															
	2.50															
		2.81														
3.59	3.50															
3.69	2.97	3.55														
3.39																
	2.50	2.51														
	3.20															
2.85	3.61	3.59														
4.85	3.40	4.06														
3.02	3.61	3.42														
3.39	4.09	3.36														
2.55																
3.15		2.99														
		2.51														
	2.50															
		-0.20														
3.02	2.20	2.08	28	0	0	0	1	0	0	0	0	0	1	0	0	0
1.30	1.38	1.36	29	0	0	0	1	0	0	0	0	0	1	0	0	0
0.60		0.78	30	0	0	0	1	0	0	0	0	0	1	0	0	0
0.30	1.00	1.04	31	0	0	0	1	0	0	0	0	0	1	0	0	0
-1.00			32	0	0	1	1	0	0	0	0	0	1	0	0	0
0.44		0.99	33	0	0	1	1	0	0	0	0	0	1	0	0	0
1.22	0.22	1.68	34	0	0	1	1	0	0	0	0	0	1	0	0	0
1.09	0.54	0.04	35	0	0	1	1	0	0	0	0	0	0	0	0	0
	-1.73	-0.70	36	0	0	1	1	0	0	0	0	0	0	0	0	0
-0.23	0.66	-0.05	37	0	0	1	1	0	0	0	0	0	1	0	0	0
0.90	0.17	0.90	38	0	0	1	1	0	0	0	0	0	0	0	0	0
-0.51	-0.51	-0.02	39	0	0	0	0	0	0	0	0	0	1	0	0	0

25 webs with body mass and population were published online [14 May 2009] :

- occurrence and abundance of species
- feeding guilds and trophic relationships
- environmental conditions (pH, SOM …)



Naturwissenschaften (2006) **93**

Scaling

Better Organic Matter

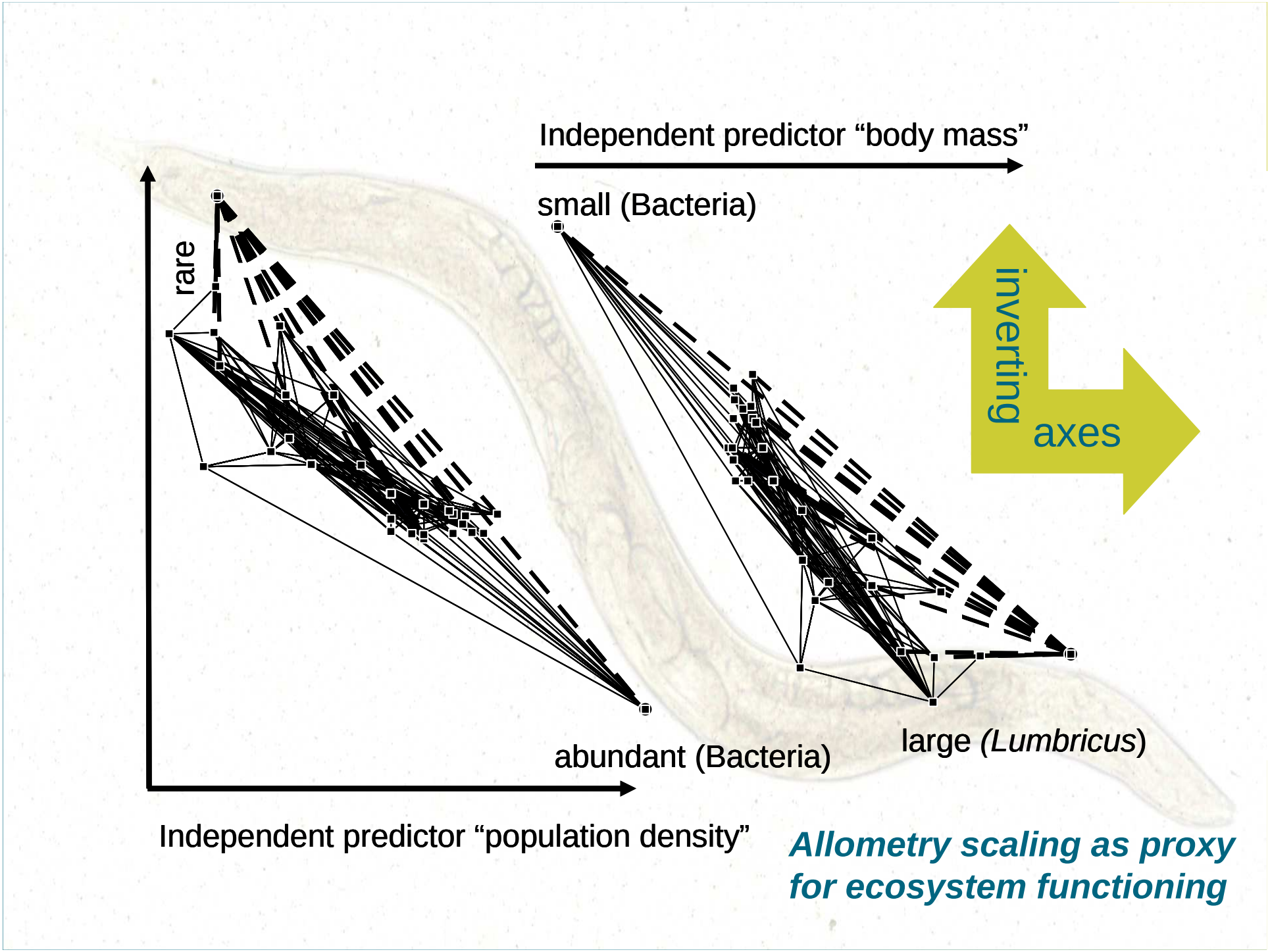
EFFECT

$R^2 = 0.622$

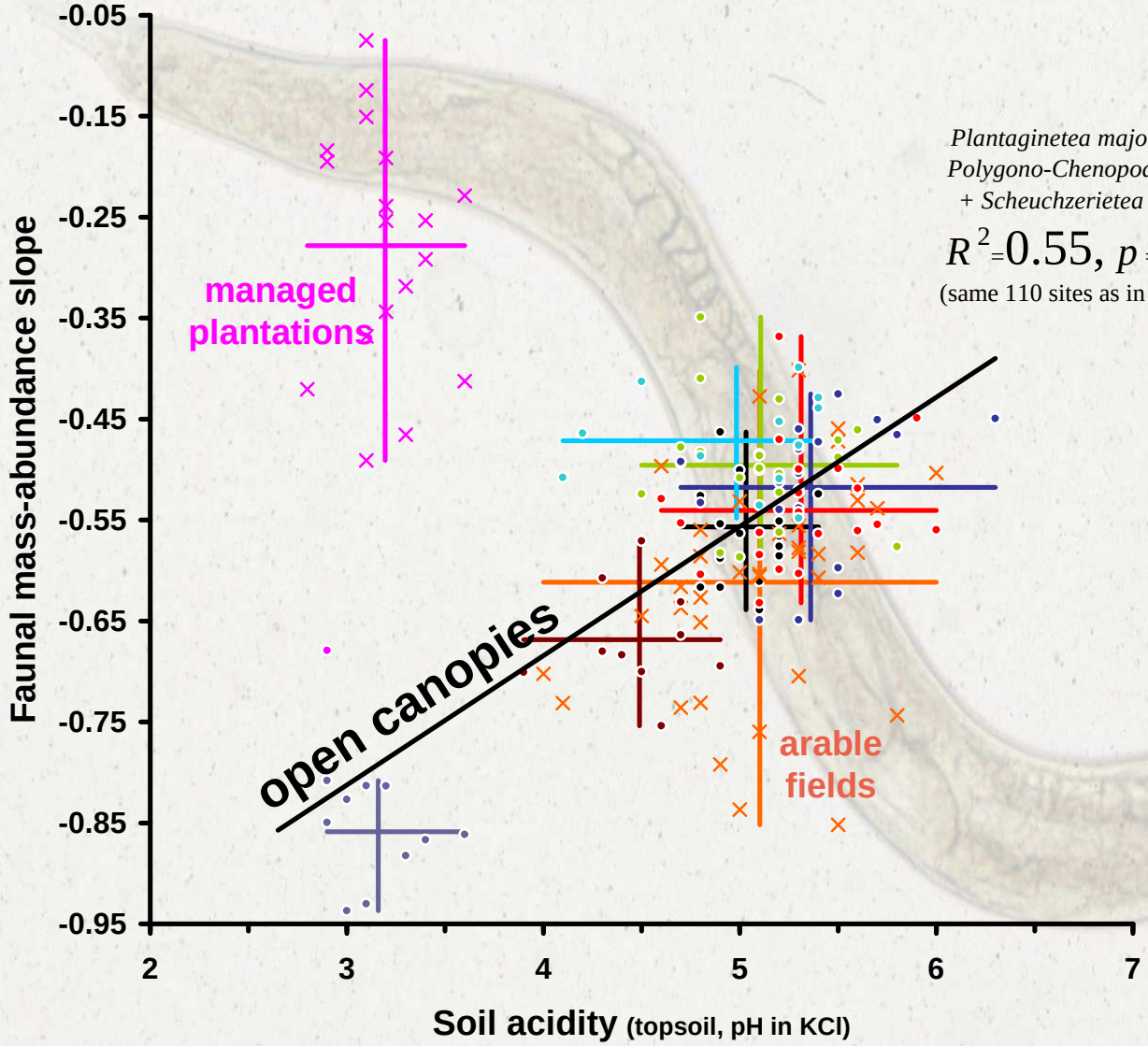
Numerical abundance (log_{10} individuals)

Average body mass (log_{10} micrograms)

SAME FOOD WEB AS IN THE PREVIOUS SLIDE



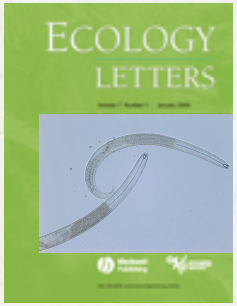
Merging grasslands together, as vegetation ecologists do, we get :



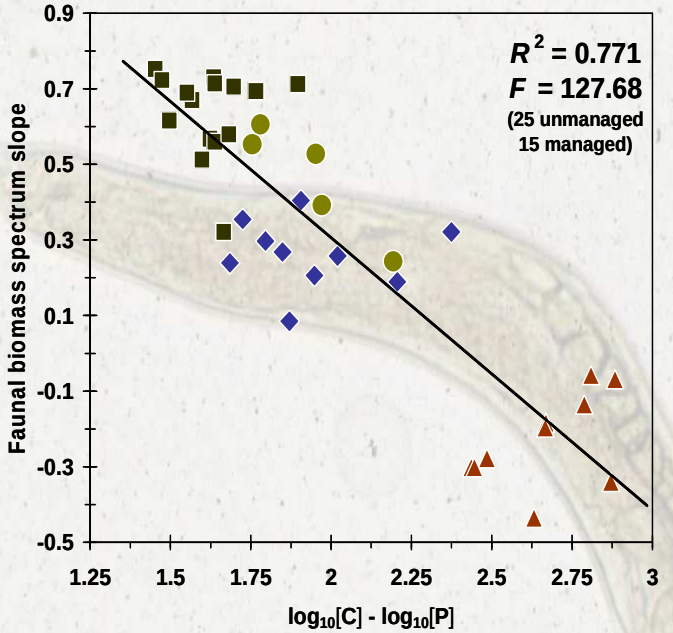
Plantaginetea majoris + *Filipendulion* + *Polygono-Chenopodietalia* + *Secalietalia* + *Scheuchzerietea* + *Nardo-Callunetea*

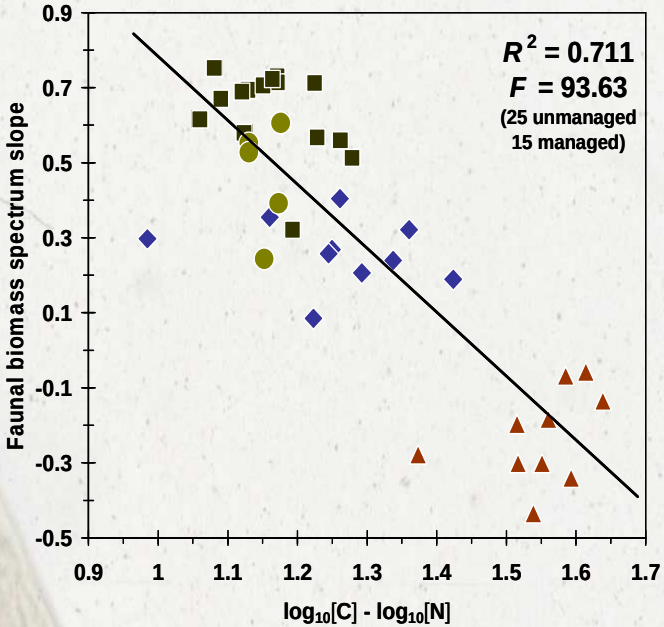
$R^2 = 0.55$, $p = 10^{-20}$, $n = 110$

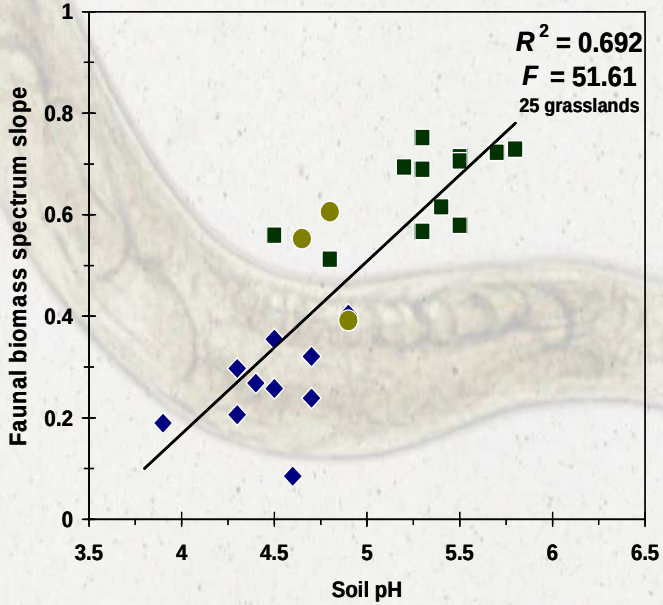
(same 110 sites as in *Ecology Letters* 2005)



Other 60 webs excluded for phenological reasons during sampling efforts : all **arable fields** had no vegetation in the Winter, and all **pine forests** no understore in late Fall

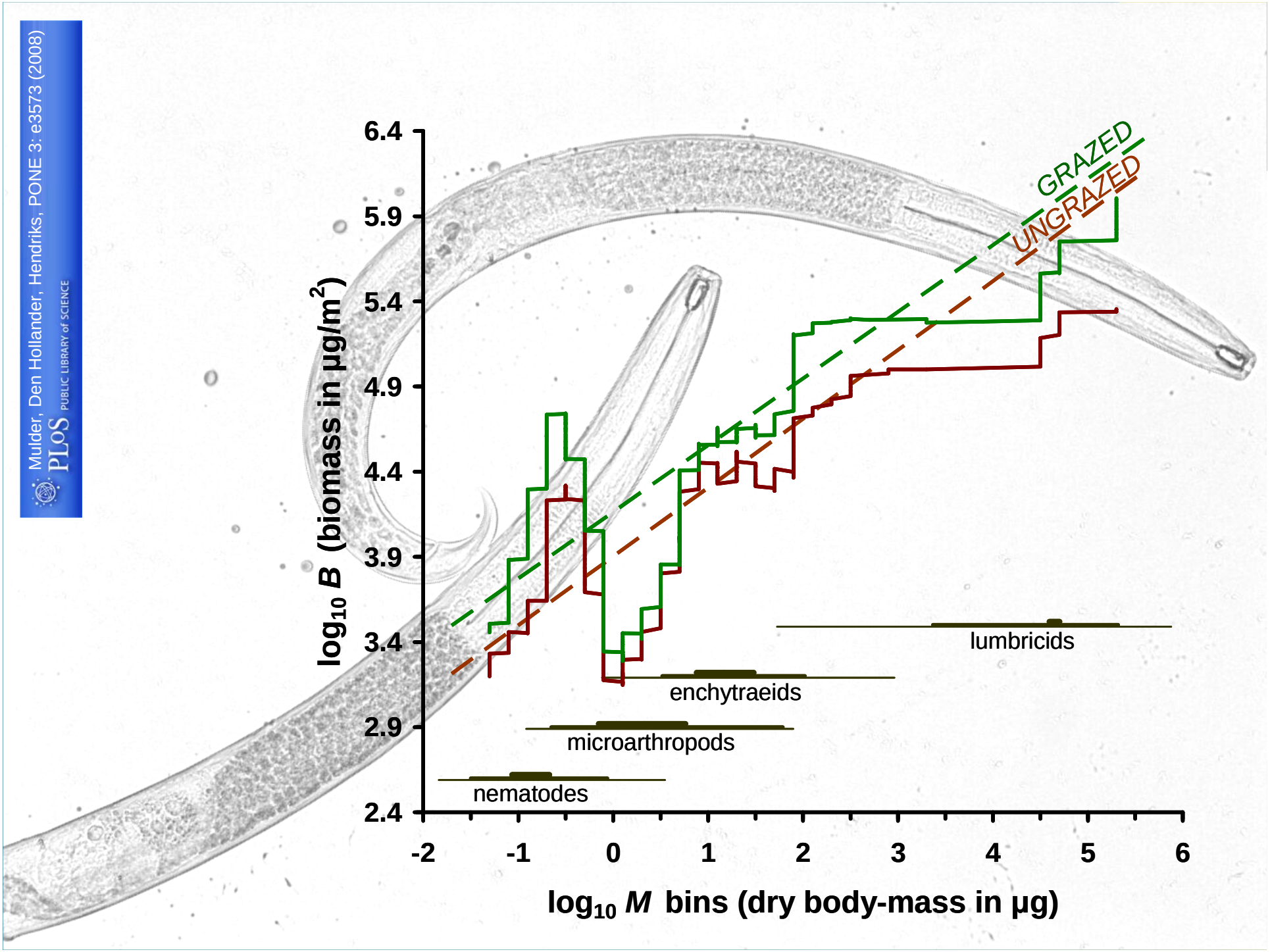


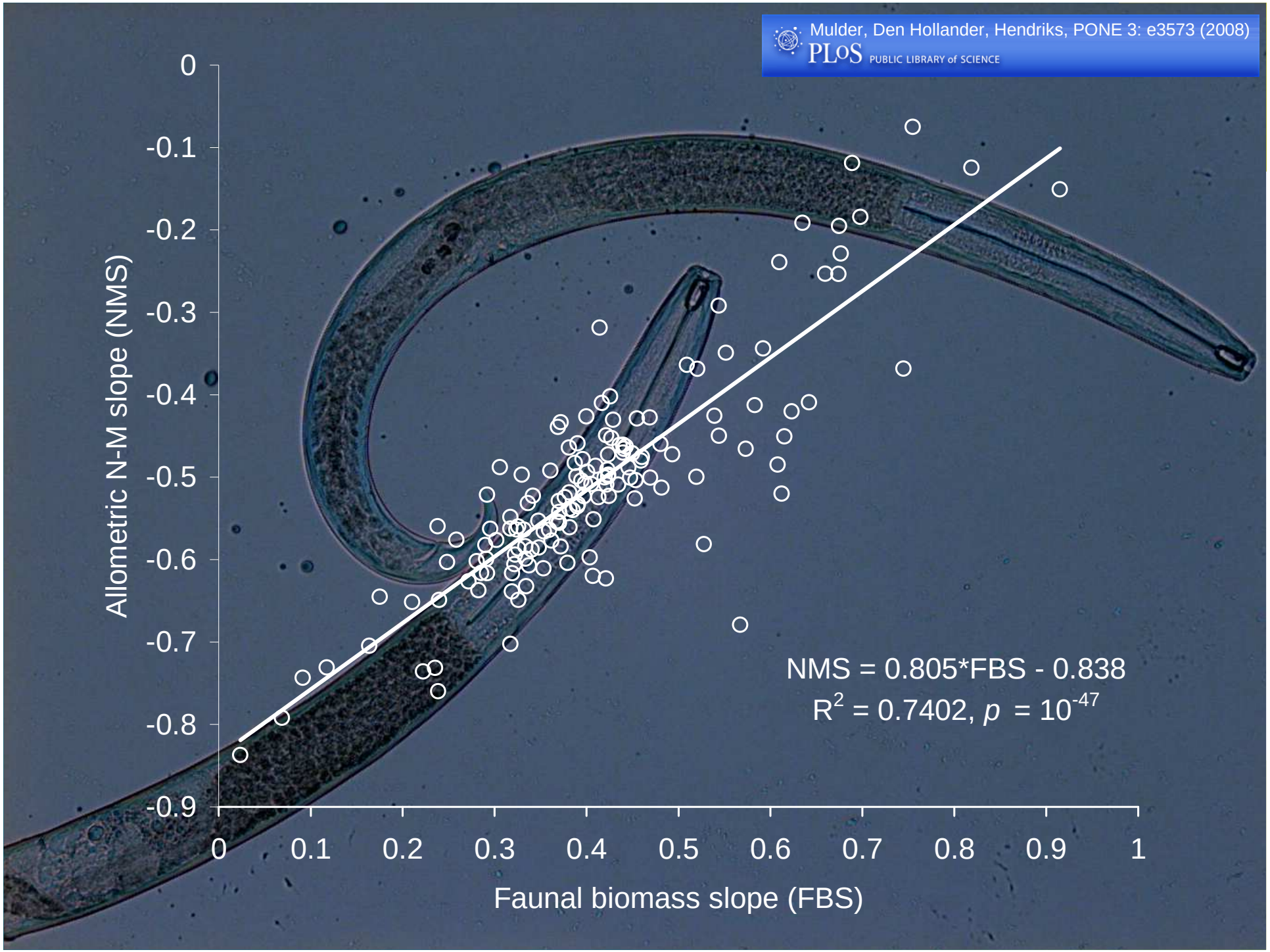




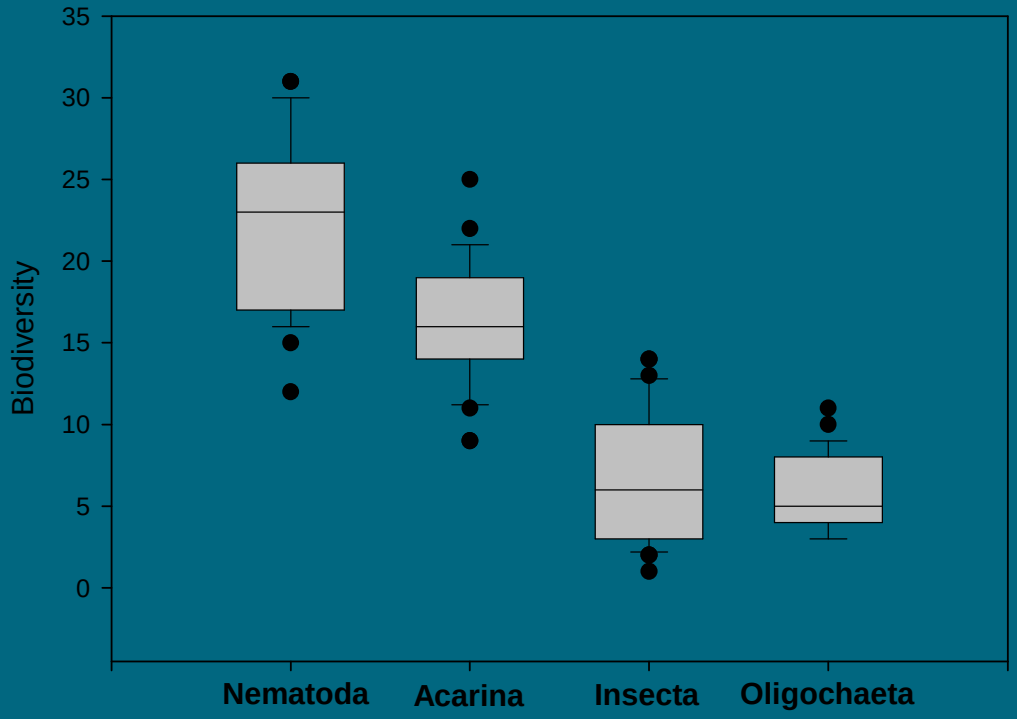
Relationships between allometric scaling and ecological stoichiometry. Clockwise: the log-transformed C : P and C : N ratios and the soil acidity as stoichiometrical predictors of the slope of the biomass spectrum of soil invertebrates. The faunal biomass spectrum slope is an index of how community patterns shifted by subtle changes in the nutrient ratios. The biomass spectrum slopes remain positively correlated with the concentrations of N (p < 0.01) and P (p < 0.0001), but not with C. The pastures are given as squares, the meadows as diamonds, and the heathlands as triangles. Control plots of a long-term experiment (*Biology and Fertility of Soils* 2009) as circles.

Mulder and Elser, *Global Change Biology* 15 (2009)
Mulder, Den Hollander, Vonk, Rossberg, Jagers op Akkerhuis, Yeates, *Naturwissenschaften* 96 (2009)





Nodes of taxa with low body-mass average occur more often, as expected from theory

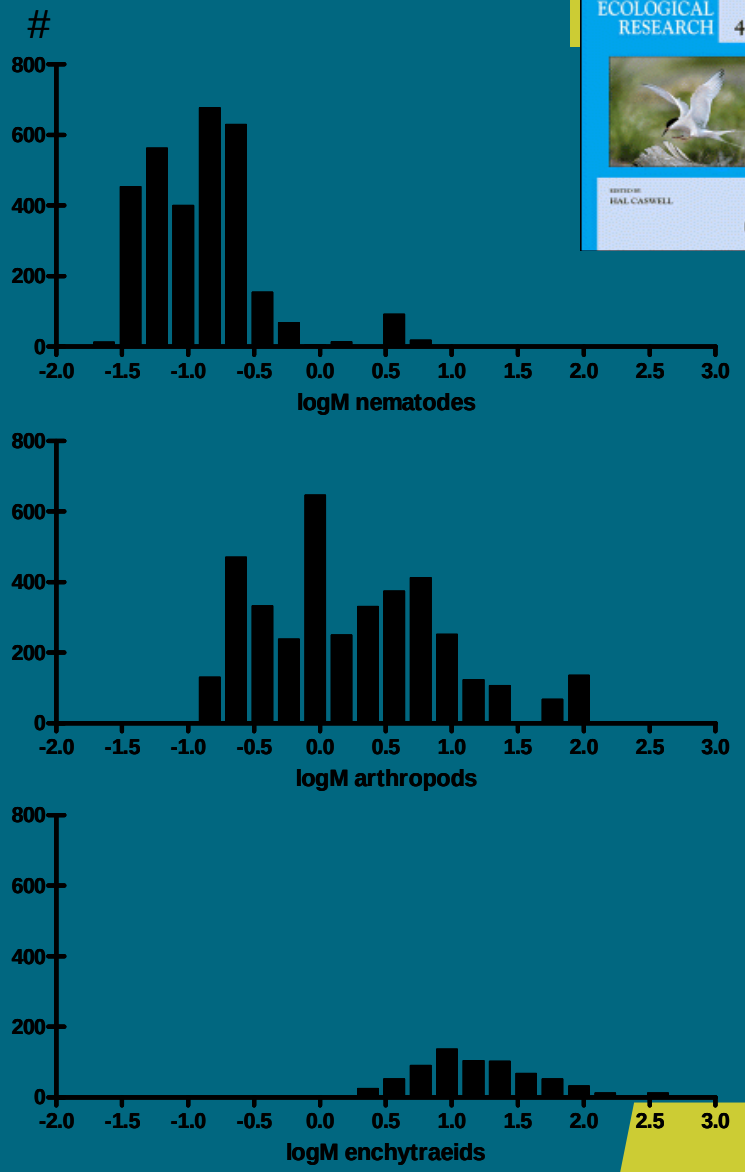


Mulder, Den Hollander, Schouten, Rutgers

Ecological Complexity 3: 219-230 (2006)

Reuman, Cohen, Mulder

Advances in Ecological Research 41: 45-85 (2009)



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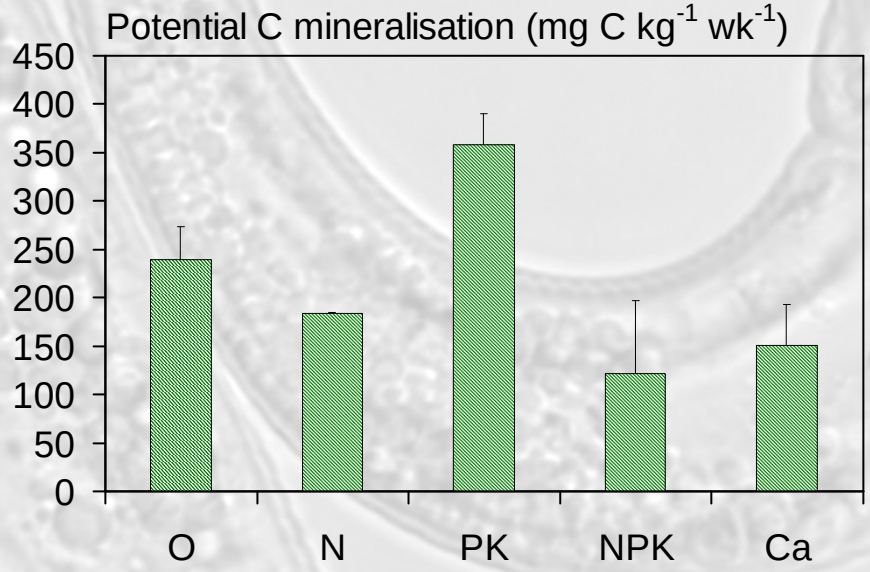
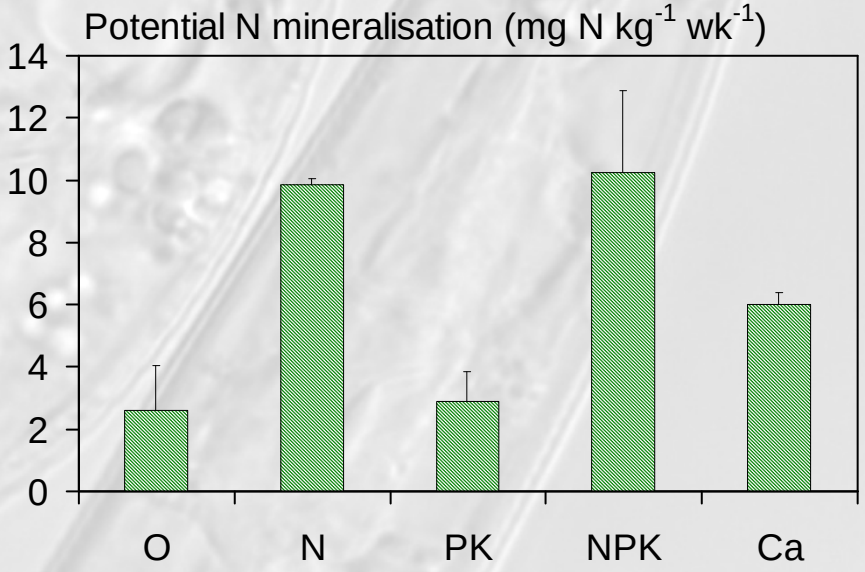
OSSEKAMPEN

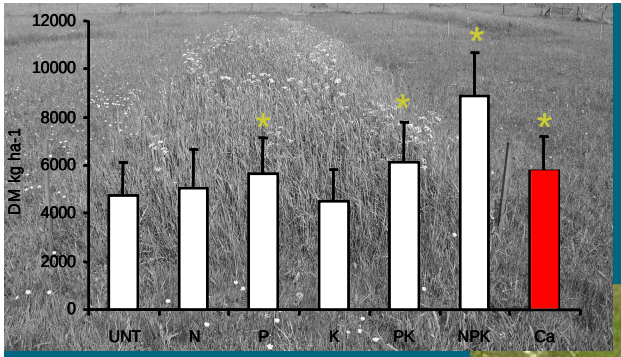
Carbon mineralisation: reflects higher ***fungal*** biomass

Nitrogen mineralisation reflects N fertilization and high ***bacterial*** activity with Ca





There is a general belief that a high fungal/bacterial ratio is indicative of a more natural soil system, with high nutrient retention and low losses (Van der Putten *et al.* 2001)



-0.75 ± 0.16 SE

THE OSSEKAMPEN EXPERIMENT

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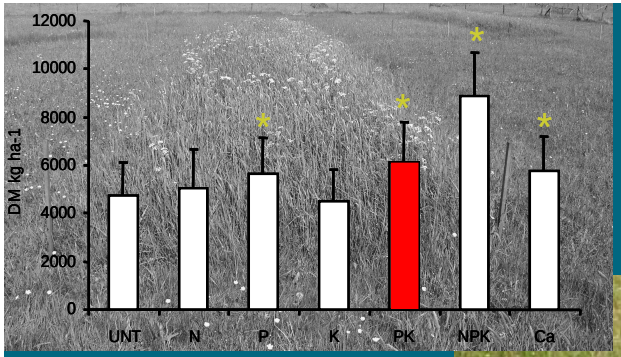

-0.70 ± 0.15 SE

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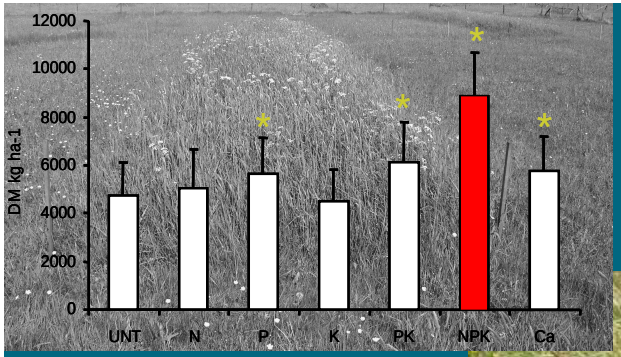

-0.62 ± 0.13 SE

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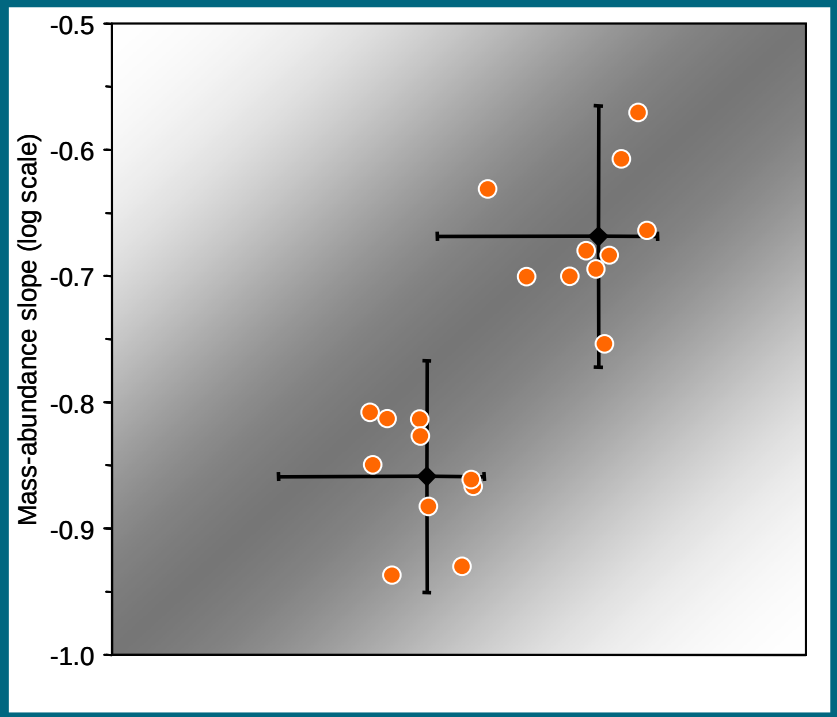
The entire structure of the soil community reflects soil abiotics

P

N

C



Size matters

[P]

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- The mass-abundance relationships (i.e., scaling exponents) CHANGE.
- Liming and fertilization ENHANCE mass-abundance relationships.
- Let us bridge the gap between soil food-web structure and SERVICE.

THANK YOU FOR YOUR ATTENTION

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