Relationships between earthworm abundance and preferential flow paths

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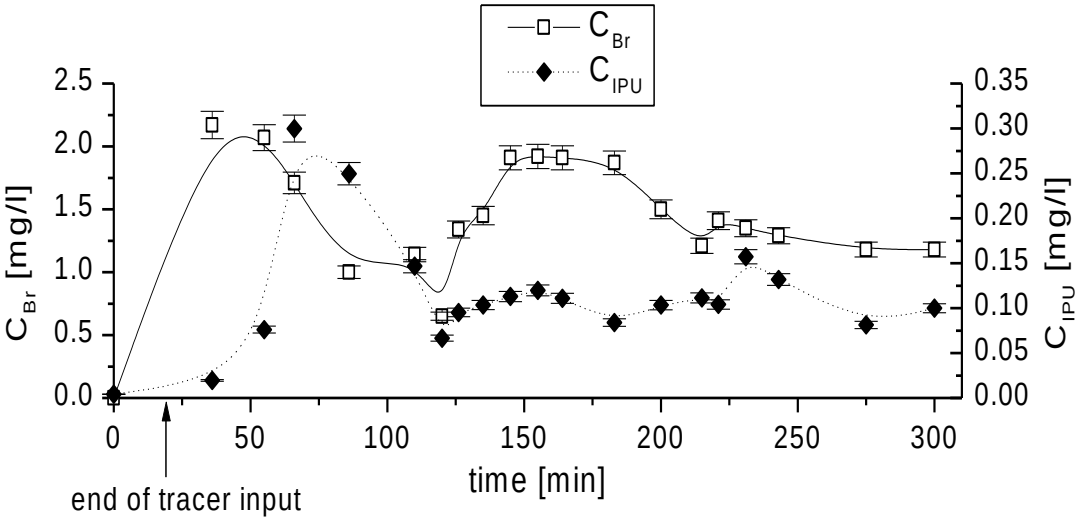
HydroEco´2011

Motivation

Bromide and Isoproturon application on tile drained arable land:

- fast breakthrough in 1.2 m depth
- Tracer: 20 min, IPU peak: 50 min



Tracer experiments:
Earthworm burrows as transport pathways

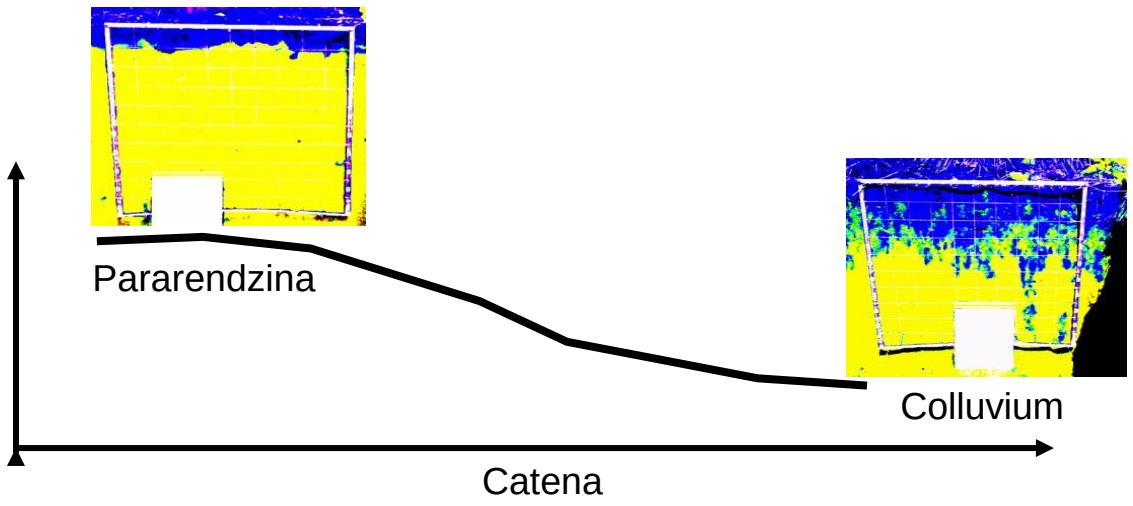
Zehe E, Flühler H, 2001. Slope scale distribution of flow patterns in soil profiles. J Hydrol 247: 116-132.

Zehe E, Flühler H, 2001. Preferential transport of isoproturon at a plot scale and a field scale tile-drained site. J Hydrol 247: 100-115.

Motivation

Spatial organisation of earthworm activity:

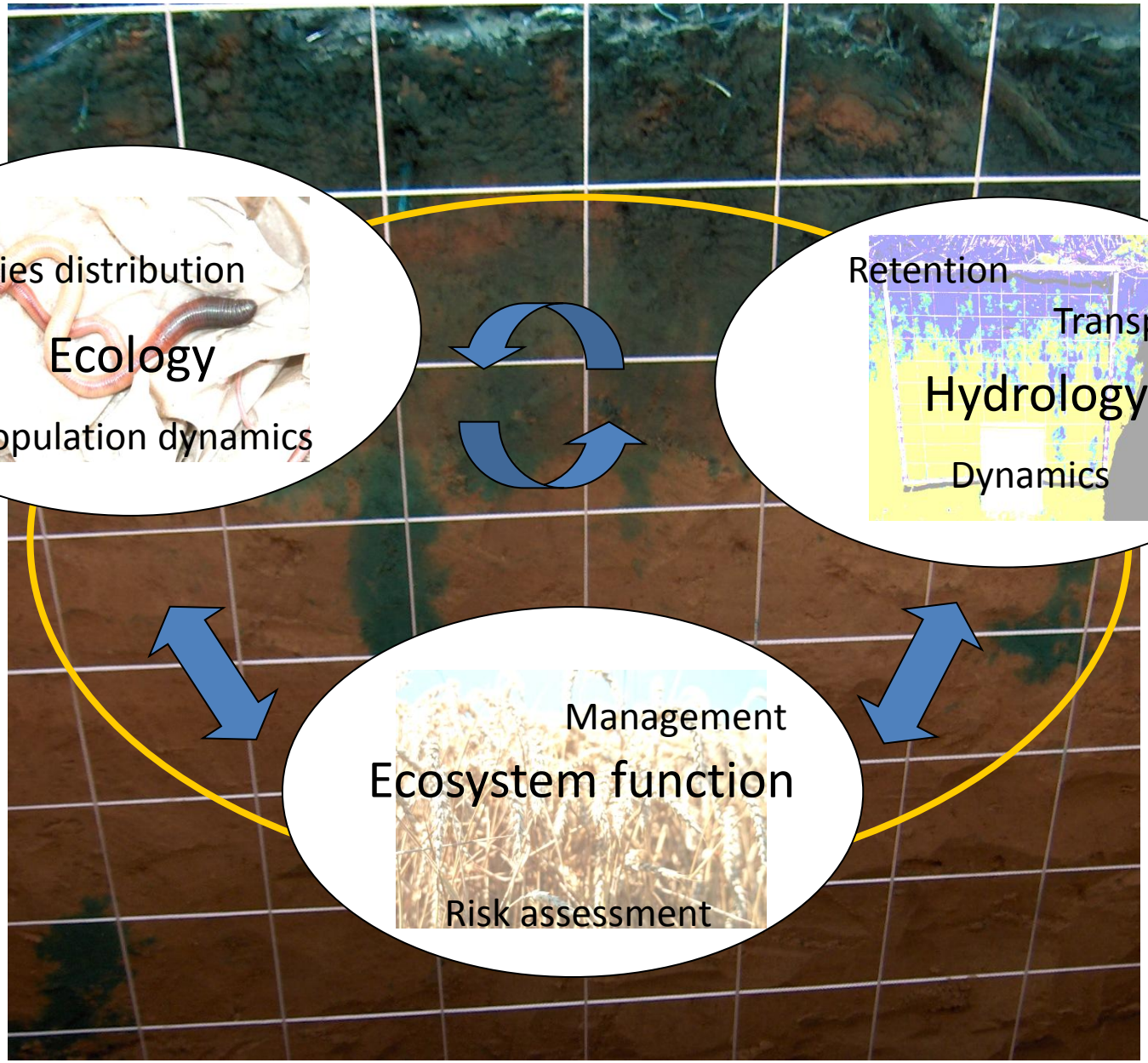
- controls transport of water and solutes
- depends on habitat preferences and soil catena



Zehe E, Flühler H, 2001. Slope scale distribution of flow patterns in soil profiles. J Hydrol 247: 116-132.

Zehe E, Maurer T, Ihringer J, Plate E, 2001. Modeling water flow and mass transport ... Phys Chem Earth 26 (7/8): 487-507.

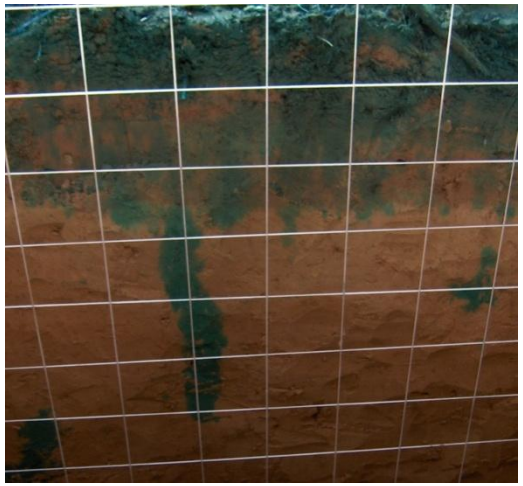
BIOPORE Project



BIOPORE aims

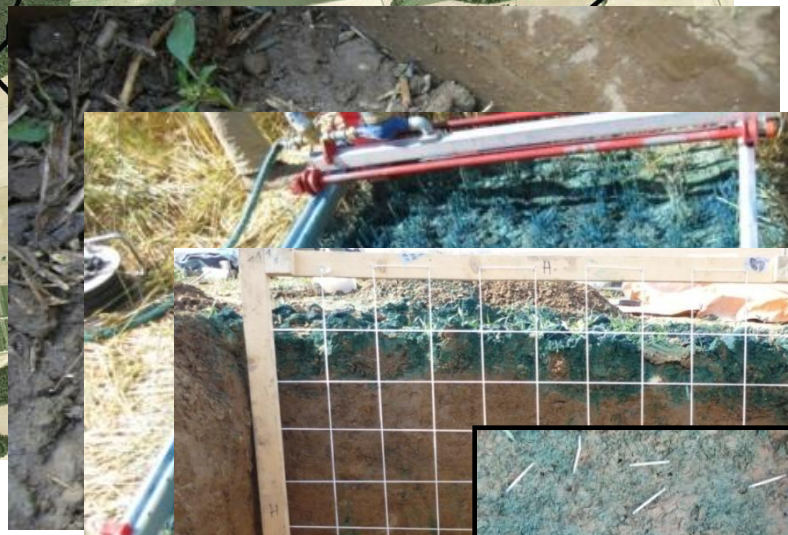
Integrated ecohydrological modeling

- Spatial earthworm distribution patterns
- Small scale population dynamics
- Flow and transport in structured soils



- Coupling earthworm distribution with hydrological modelling
- Spatiotemporal patterns of transport and degradation of agrochemicals considering feedbacks between earthworms and hydrology

Measurements



At 16 locations in the Weiherbach Catchment :

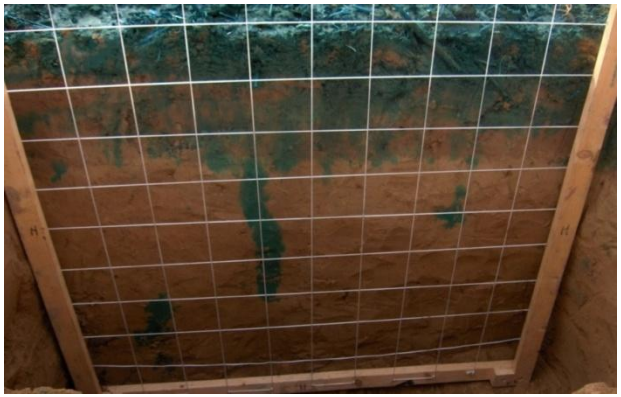
- earthworm extraction;
- dye tracer rainfall experiments with approx. 43 mm/h on 1 m2;
- profile excavation (3 vertical, 3 horizontal);
- macropore counting and labeling in size groups (<2 mm, 2-6 mm, >6 mm) and stained or non-stained;
- environmental predictors;
- soil physical measurements.

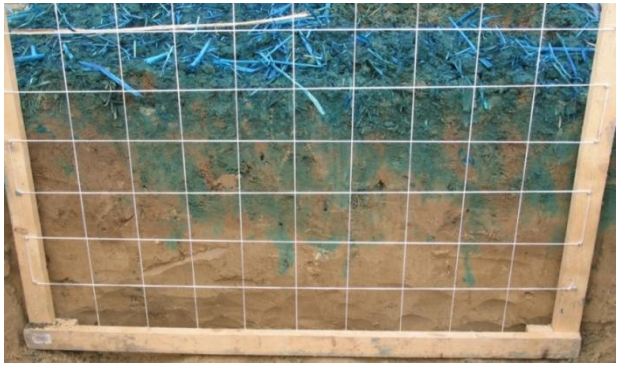
Some infiltration patterns

Note: total infiltration is the same for each profile!!!

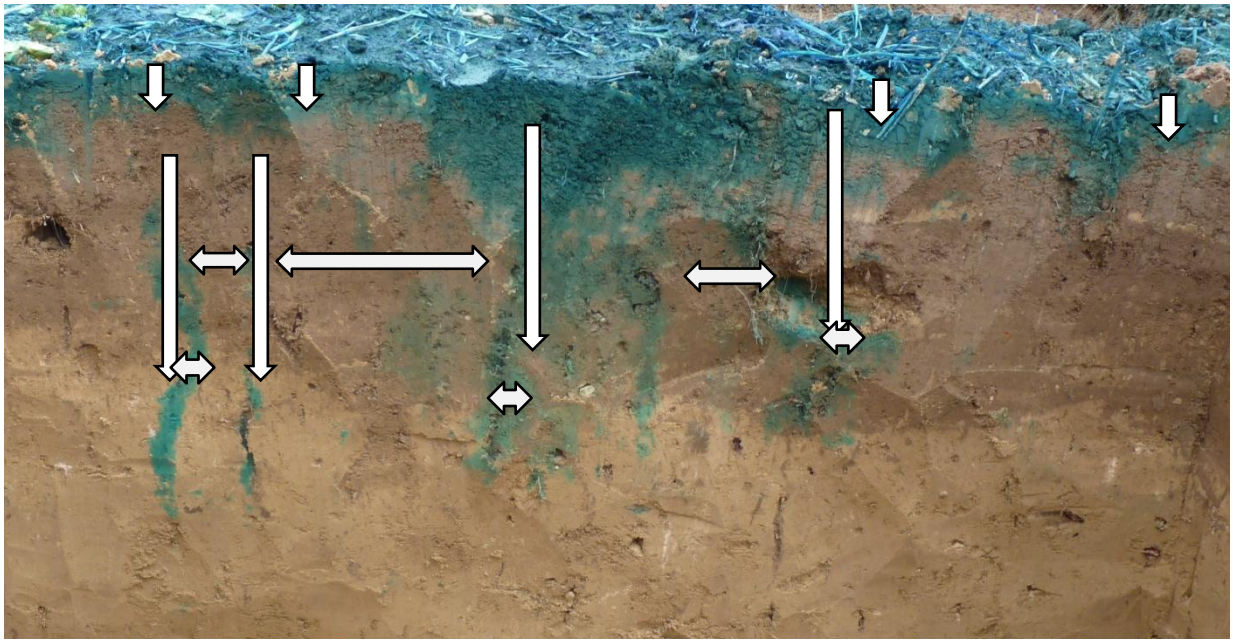
Variation in:

- homogeneous infiltration at soil surface
- pattern of macropores
- interaction between macropores and soil





Macropore flow modelling



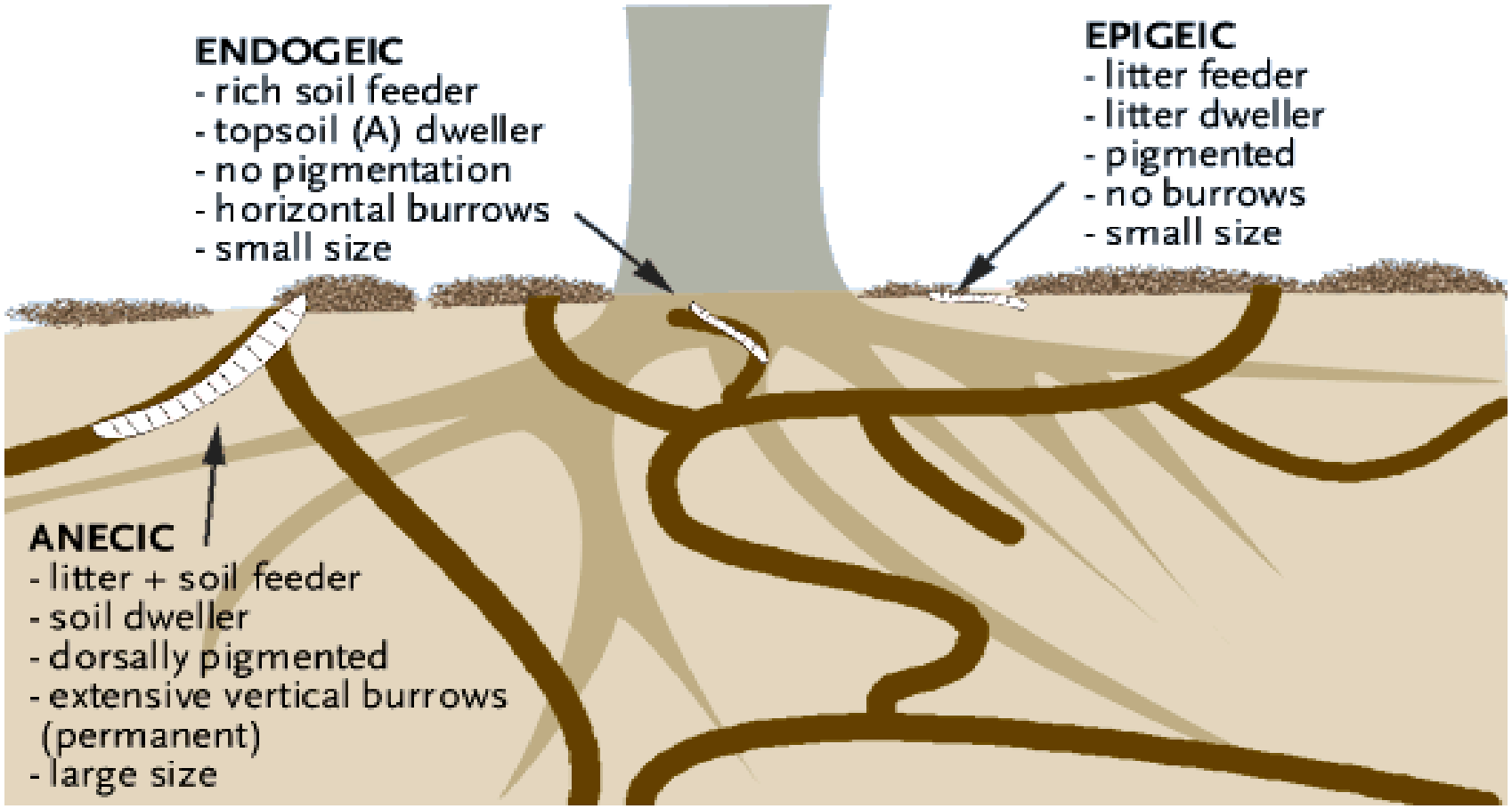
Necessary information for macropore modelling

- matrix flow (Richards equation, based on soil physical properties)
- macropore flow characteristics (e.g. Richards equation, tube flow, direct by pass to bottom of macropores)
- spatial and temporal macropore network
- interaction between macropores and matrix

Beven K. Germann P. 1982. Macropores and water flow in soil. Water Resour Res 18(5): 1311-1325.

Van Schaik NLMB. Hendrik RFA. Van Dam JC. 2010 Parameterization of macropore flow …… Vadose Zone Journal 9: 95 -106.

Earthworm ecological types



www.nrri.umn.edu/worms/identification/ecology_groups.html

Bouché MB, 1975. Action de la faune sur les états de la matière organique dans les écosystèmes.

In: Kilbertius GORAM. Cancela da Fonseca JA ,(eds.), Humification et biodégradation. Pierron, pp. 157-168.

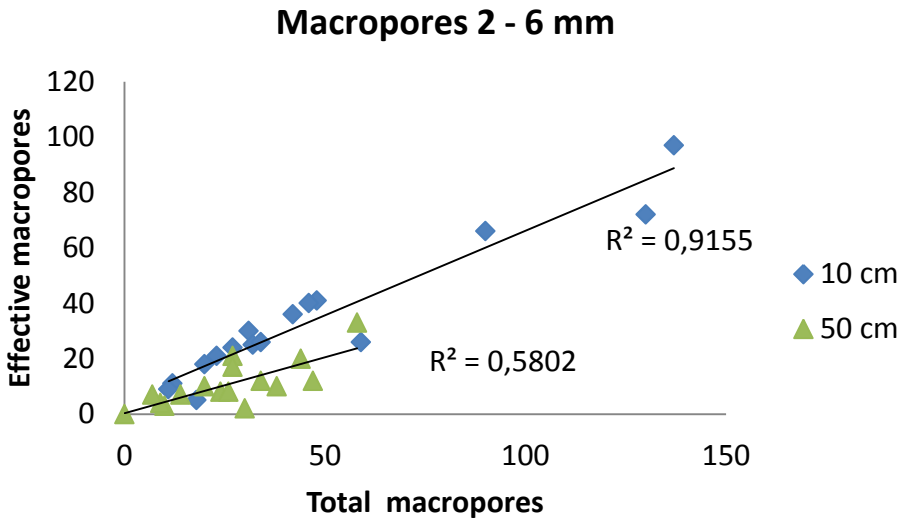
Correlations earthworms - macropores

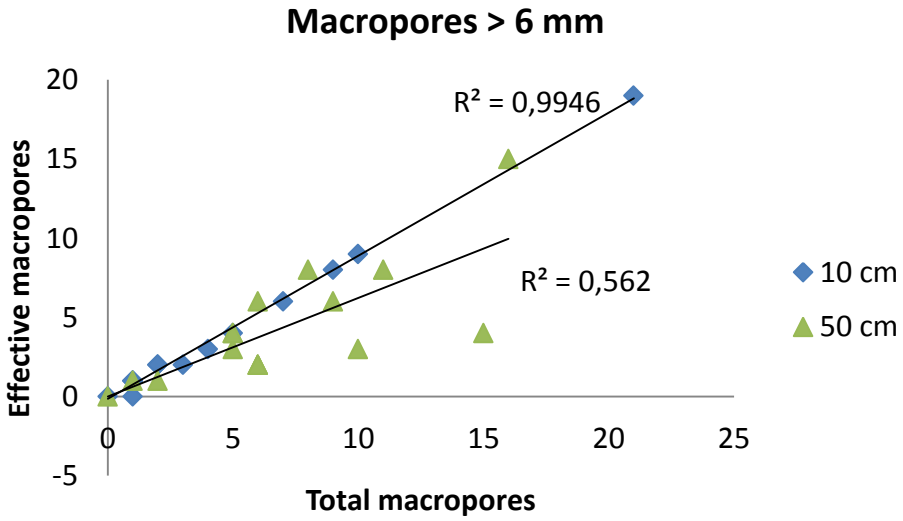
	10 cm			30 cm			50 cm		
Earthworms	<2	2-6	>6	<2	2-6	>6	<2	2-6	>6
Biomass									
Endogeic	.57	.32	.33	.08	.17	.38	.78	.37	.69
Anecic	.11	.09	.78	.25	.32	.93	.60	.35	.83
Amount									
Endogeic	.66	.29	.40	.05	.15	.54	.79	.32	.81
Anecic	.06	.29	.76	.21	.51	.79	.55	.49	.68

Focus on small scale heterogeneity:

	earthworms per plot		average per five plots	
	30 cm	50 cm	30 cm	50 cm
	pores < 2 mm			
Endogeic	0,40	0,32	0,79	0,68
	pores 2 - 6 mm			
Endogeic	0,41	0,35	0,48	0,55
	pores > 6 mm			
Anecic	0,12	0,13	0,60	0,64

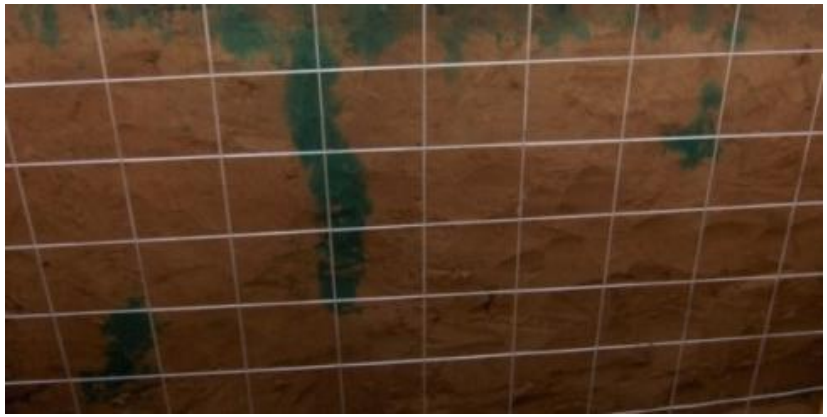
Macropore effectivity





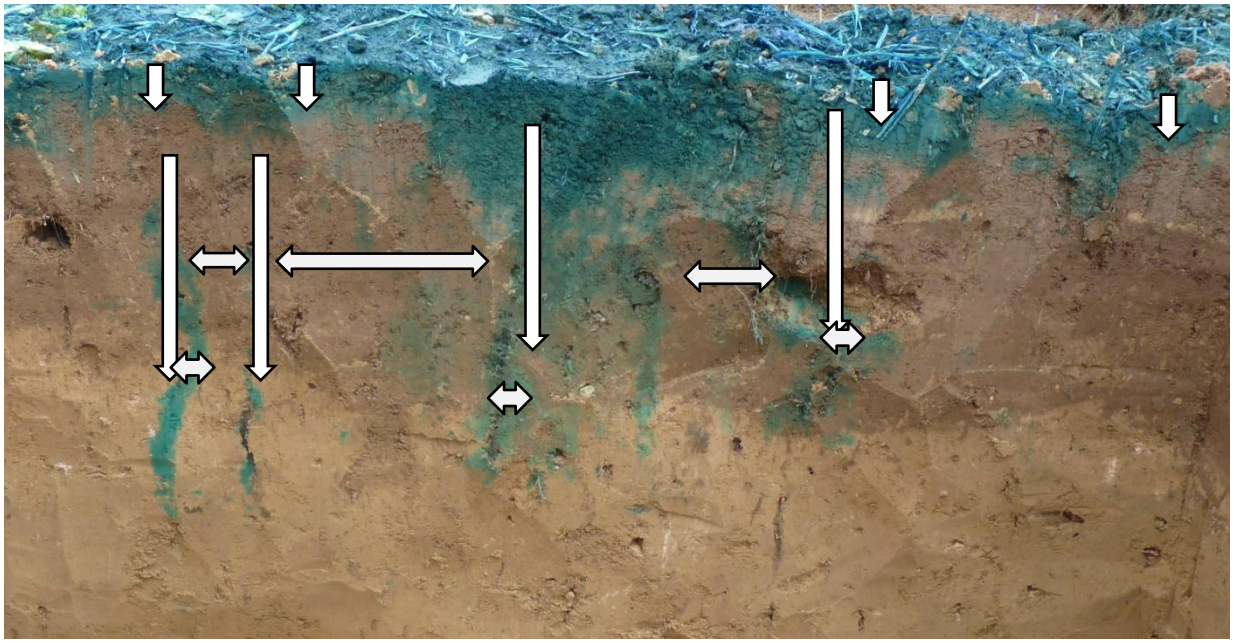
Macropore-matrix interactions

- There is not a large texture gradient in the catchment (silty loam, slightly finer soils in valley bottom)
- Typically similar macropore-matrix interactions within profiles



Variation in interactions cannot be explained with soil texture nor with soil physical measurements, such as conductivity, porosity or bulk density.

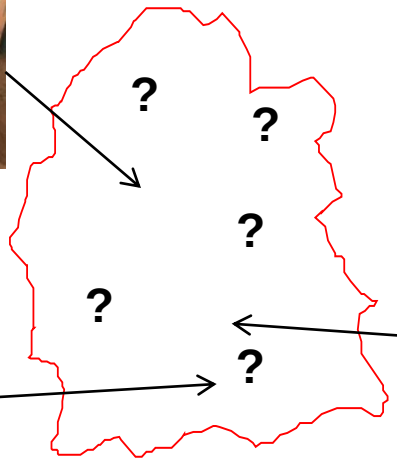
Conclusions

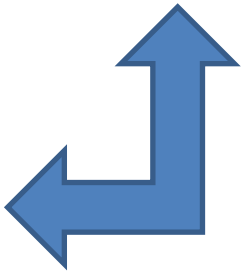


- matrix flow (Richards equation, based on soil physical properties)
- macropore flow characteristics (e.g. Richards equation, tube flow, direct by pass to bottom of macropores)
- spatial and temporal macropore network: use of earthworm distribution models of different ecological types
- interaction between macropores and matrix…… work in progress

Outlook: Spatial distribution of earthworms and macropore flow

Predictor	*Anec*
Wetness Index	-
Elevation	13 (2
Insolation	-
Slope	-
Meadow	10 (2
Trees	6 (10
Plough	14 (2
Organic Content	19 (2
Endogeic Abundance	10
Epigeic Abundance	29
Anecic Abundance	-



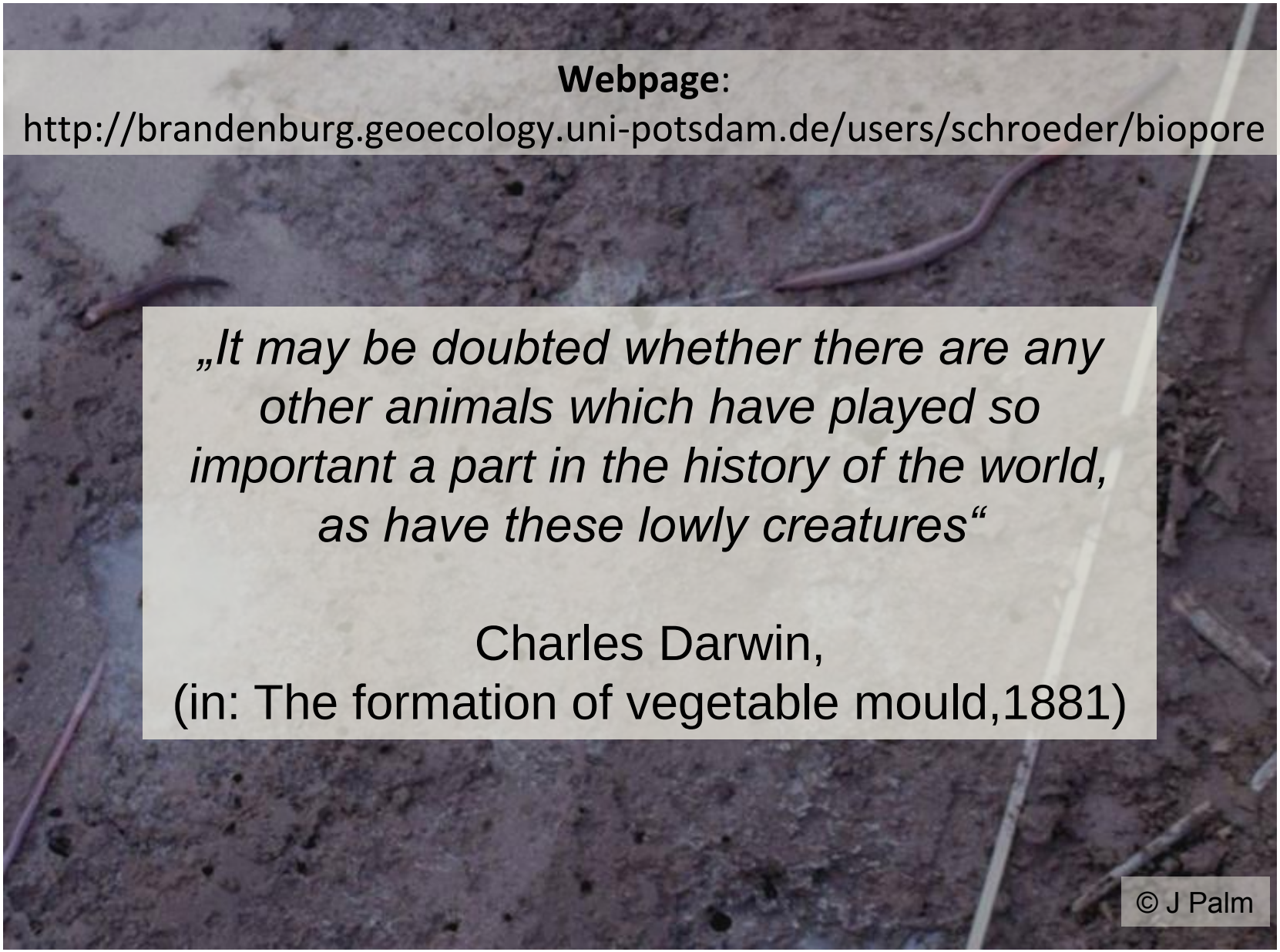


THANK YOU

Webpage:
http://brandenburg.geoecology.uni-potsdam.de/users/schroeder/biopore

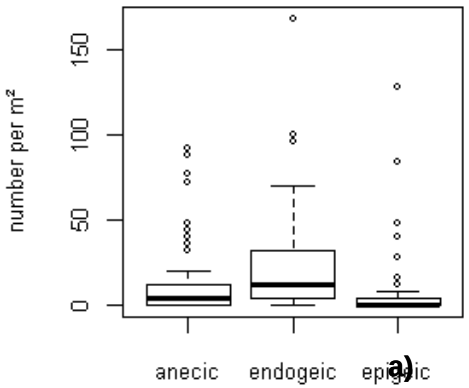
„It may be doubted whether there are any other animals which have played so important a part in the history of the world, as have these lowly creatures“

Charles Darwin,
(in: The formation of vegetable mould,1881)



Thanks to Erwin Zehe, Boris Schroeder, Juliane Palm, Julian Klaus, Marcus Morgner … and the German Science Foundation DFG

Resp curves van Juliane.....



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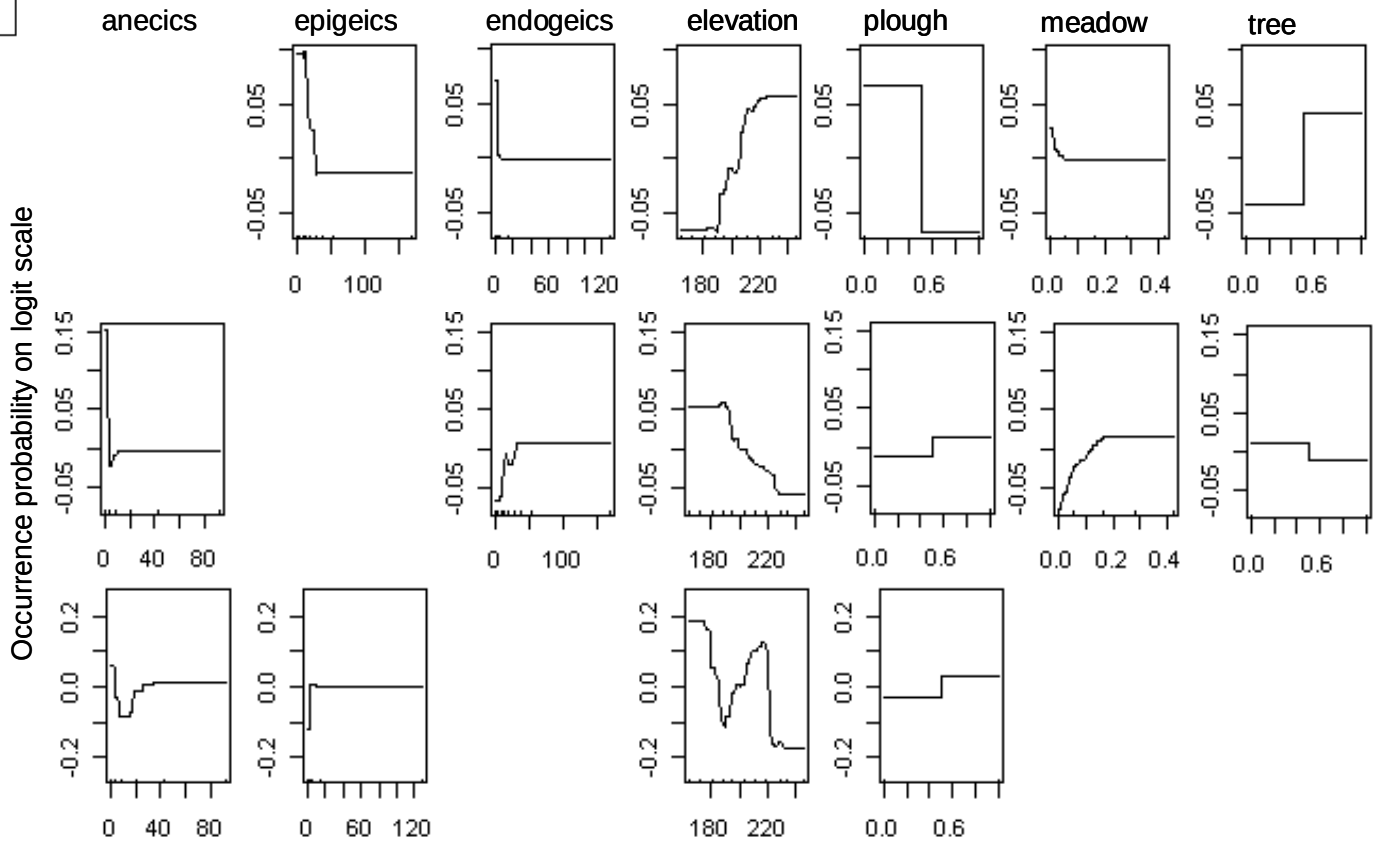

Hydrological model parameterisation

Generation of realistic heterogeneous media in Catflow (following Erwin Zehe and Julian Klaus) :

Macropores

- Density : Poisson-distributed (data: Zehe & Blöschl 2004)
- Length : Gaussian
- Burrowing activity : random walk
- Infiltration capacity : measurements

Zehe E, Blöschl G, 2004. Predictability of hydrologic response at the plot and catchment scales Water Resour Res 40: W10202.

Klaus J, Zehe E, 2010. Modelling rapid flow response of a tile-drained field site …… Hydr Proc 24:1595-1609.

Outlook

- Catchment scale prediction of earthworm distribution
- Catchment scale parameterisation of hydrological model
- Including feedbacks between earthworms and hydrology under different land-use or climate scenarios