AARHUS UNIVERSITY

November 2014

Pesticide exposure and effects on invertebrates and ecosystem functioning

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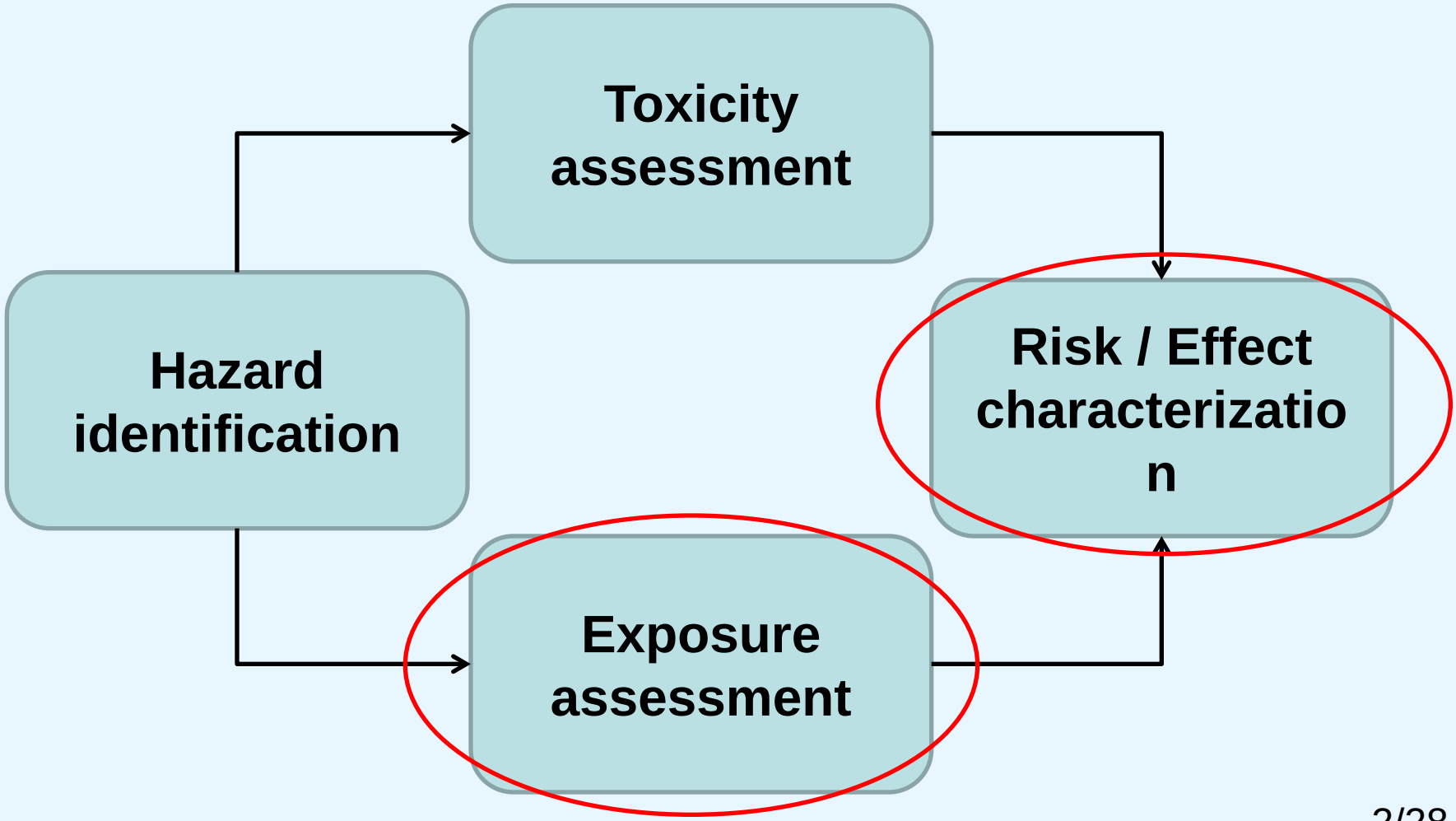
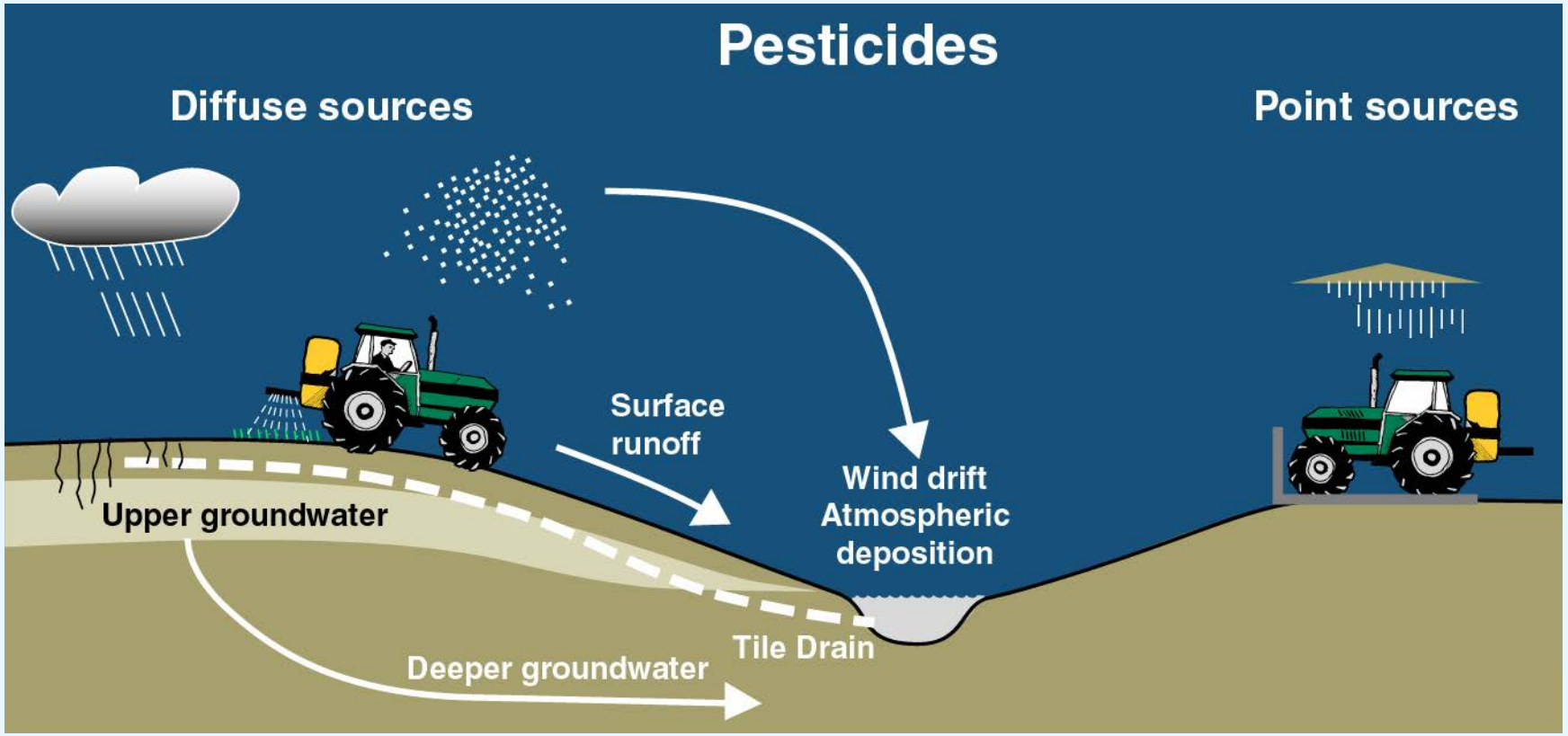
Workshop aims and content of talk



I. Major transport routes for pesticides



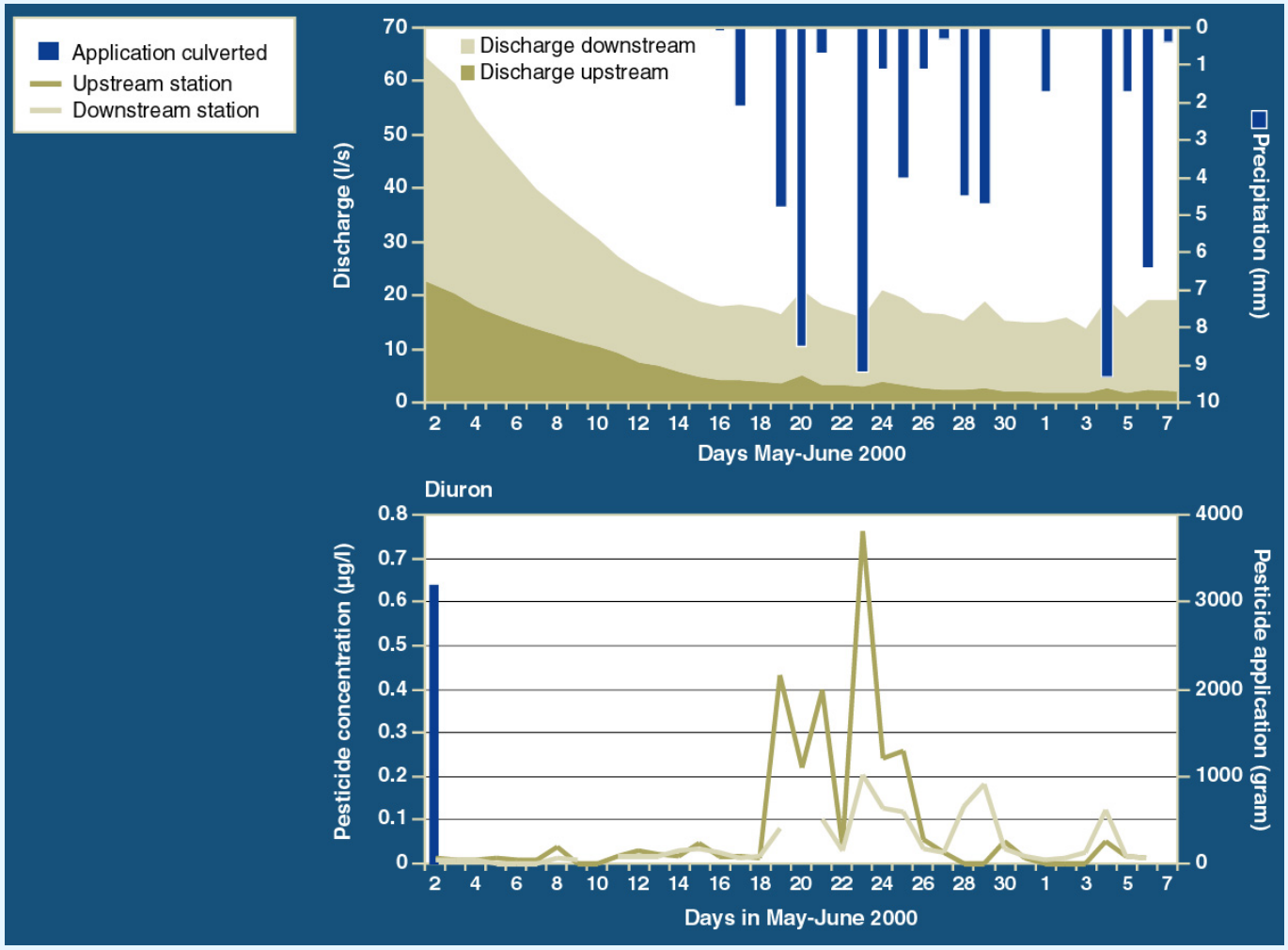
I. Frequency is similar while max. concentration is significantly higher in small streams

	Large streams		Small streams	
	Frequency (%)	Concentration Max (µg/l)	Frequency (%)	Concentration Max (µg/l)
Isoproturon	41	0.13	48	2.1
Diuron	37	0.073	29	0.36
Bentazon	25	0.028	37	1.2
Fenpropimorph	0	0	3	0.11
Dimethoat	2	0.034	4	0.12

Examples of frequency and maximum concentrations of pesticides in two stream types from the Danish Monitoring Programme (NOVANA)

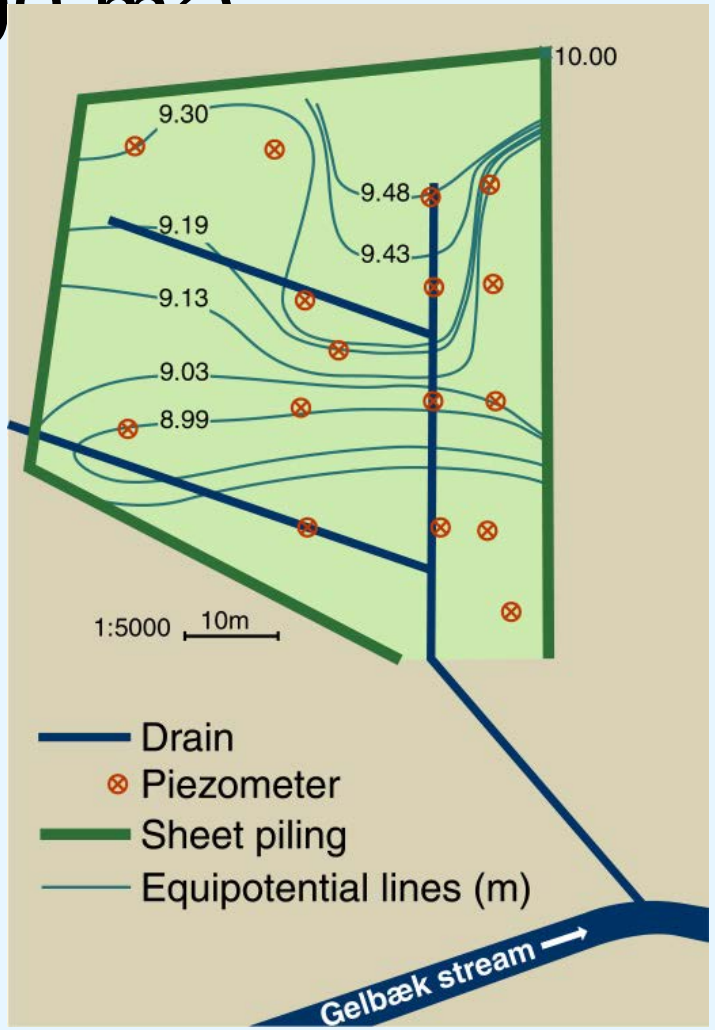
All sampling conducted with regular time intervals and independent of rain events!

I. Importance of precipitation events for transport of pesticides

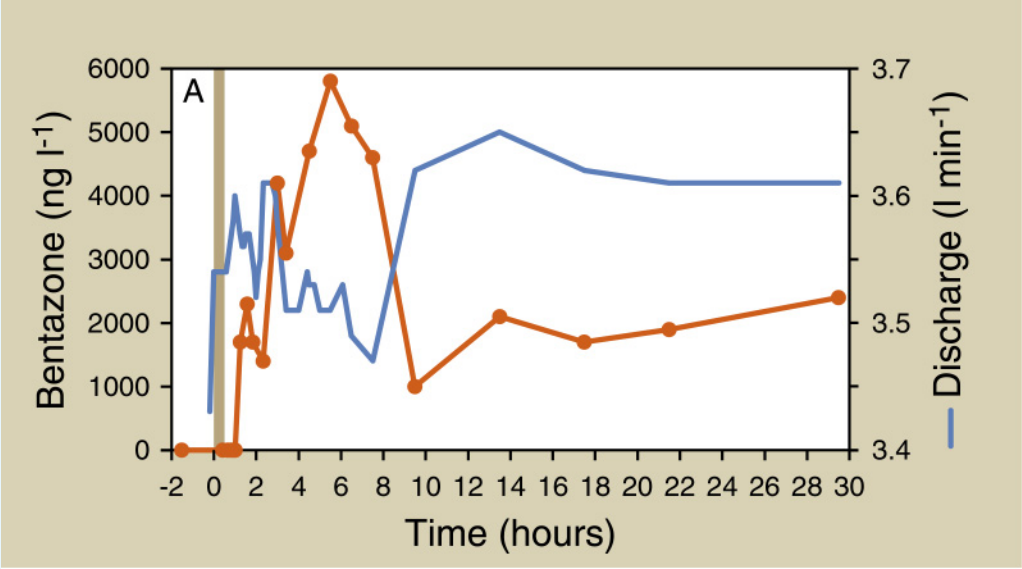


I. Experimental study in a small tile drained field plot (ca. 2800 m^2)

- **Application of three different pesticides in normal doses on the field followed by irrigation with 10 mm within 1 hour**

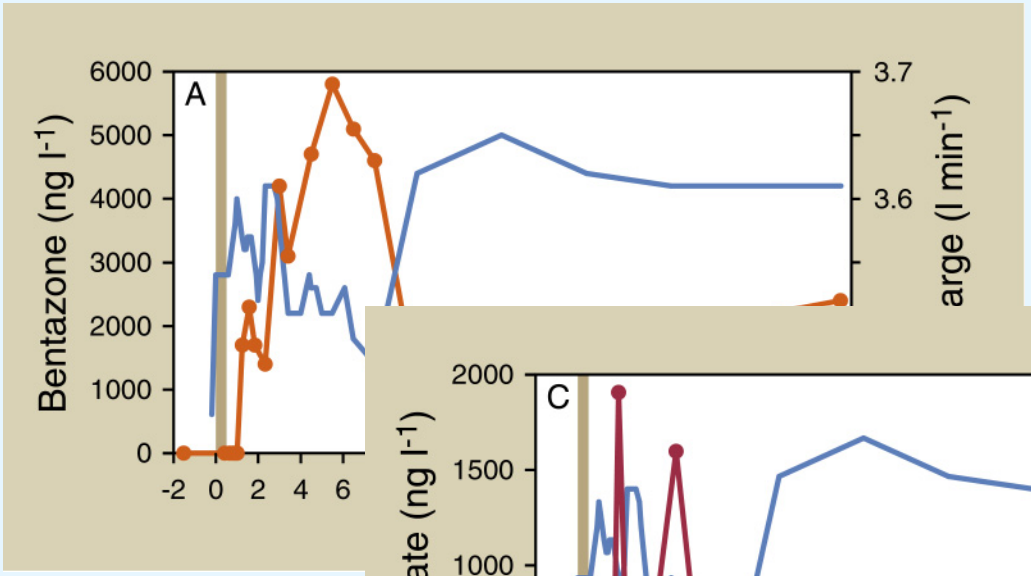


I. Drain concentration

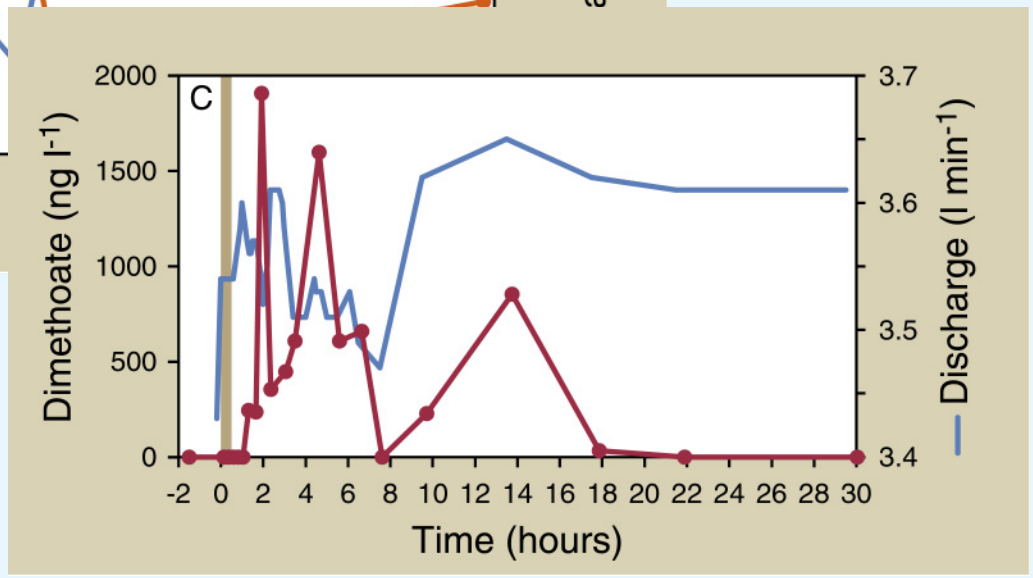


Log Kow = -0.46

I. Drain concentration

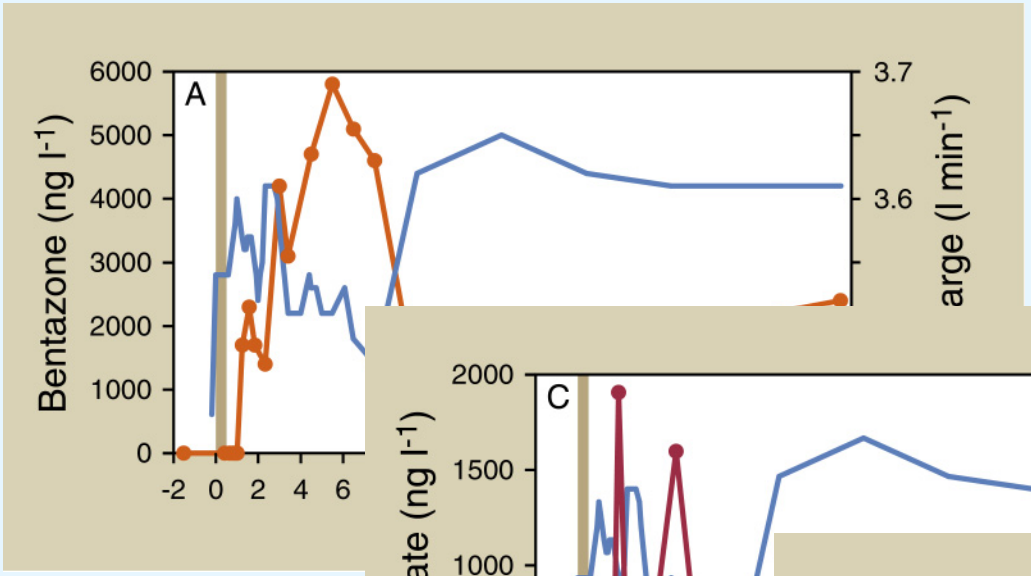


Log Kow = -0.46

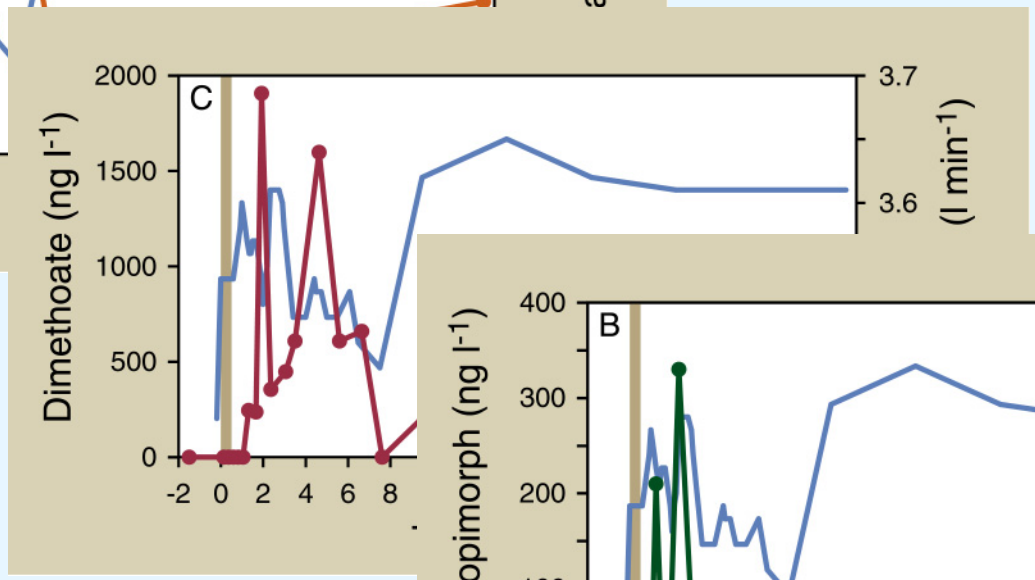


Log Kow = 0.70

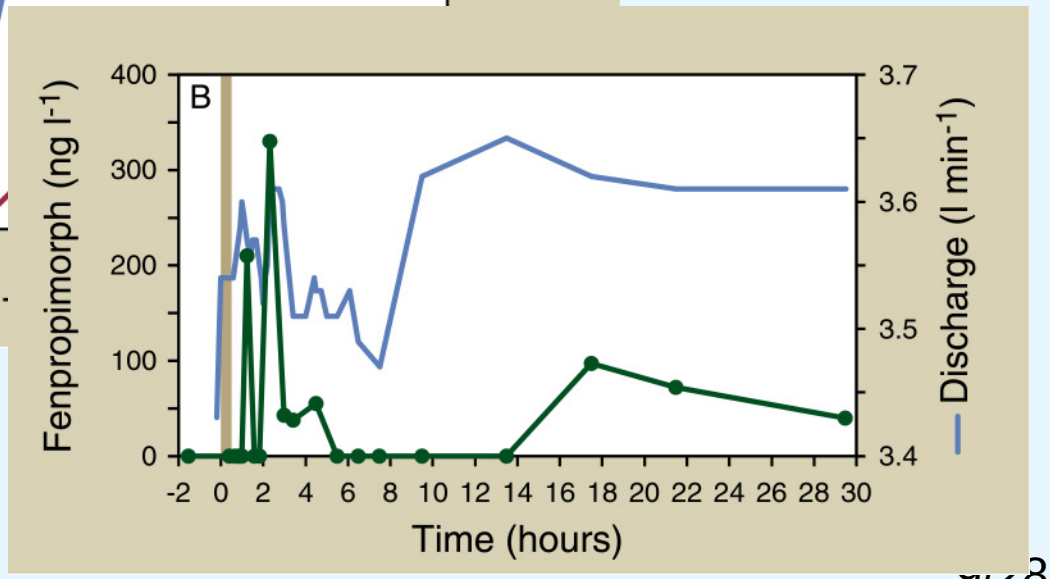
I. Drain concentration



Log Kow = -0.46

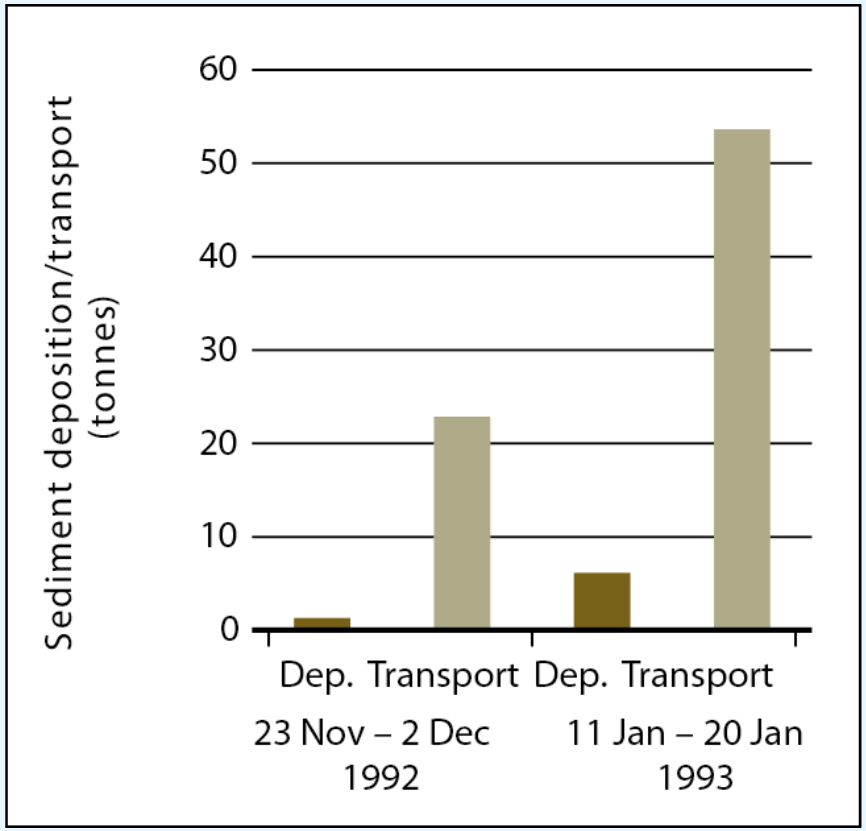


Log Kow = 0.70



Log Kow = 4.50

I. Sediment transport – important for adsorption of pesticides



- **High particle transport in agricultural streams**
- **Particles originate from bank erosion and runoff**
- **Also DOM transport is higher in agricultural catchments**
- **Adsorption of pesticides to (organic) solids prolongs their half lifes**

Environ Science &
Article
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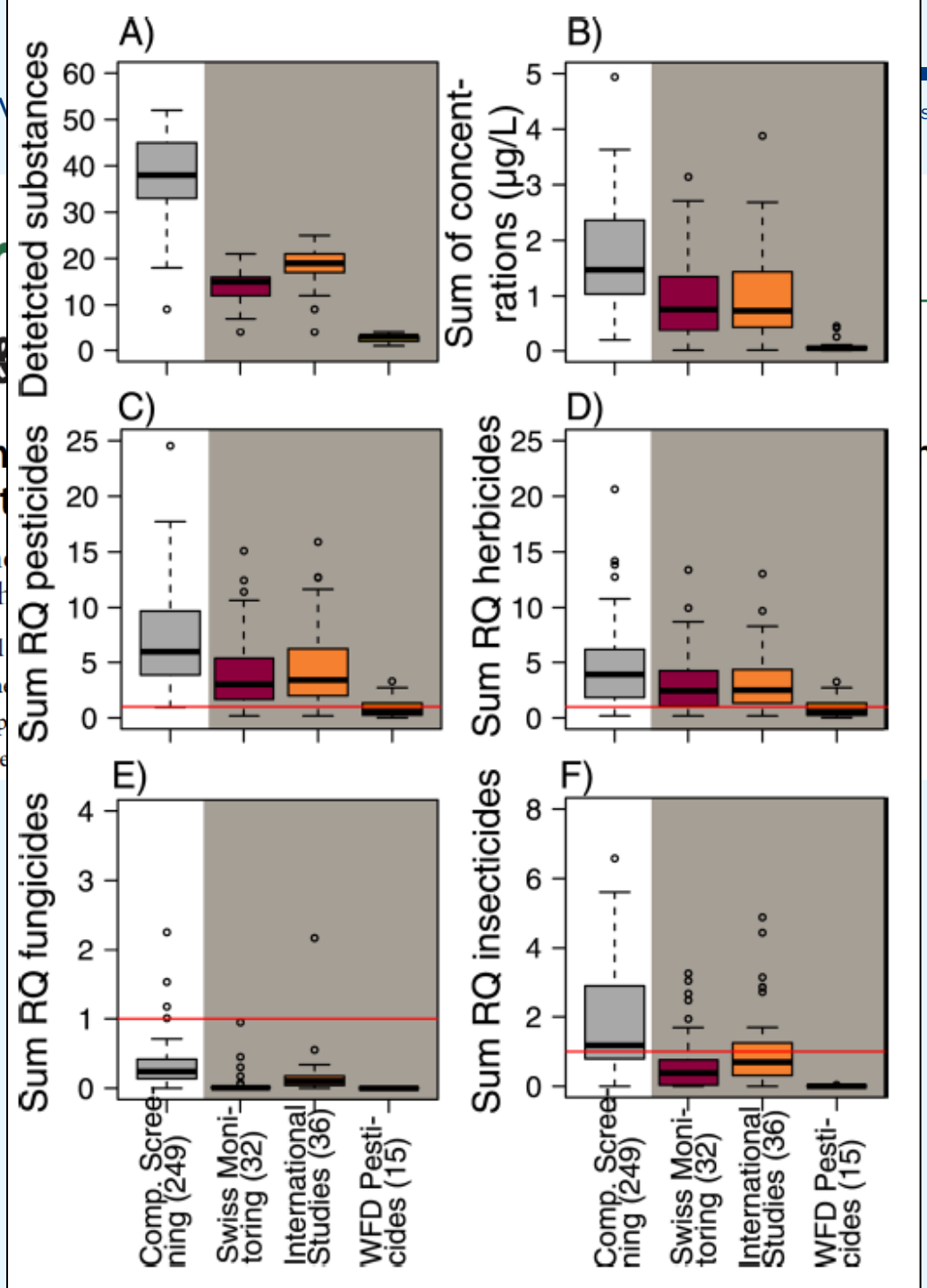
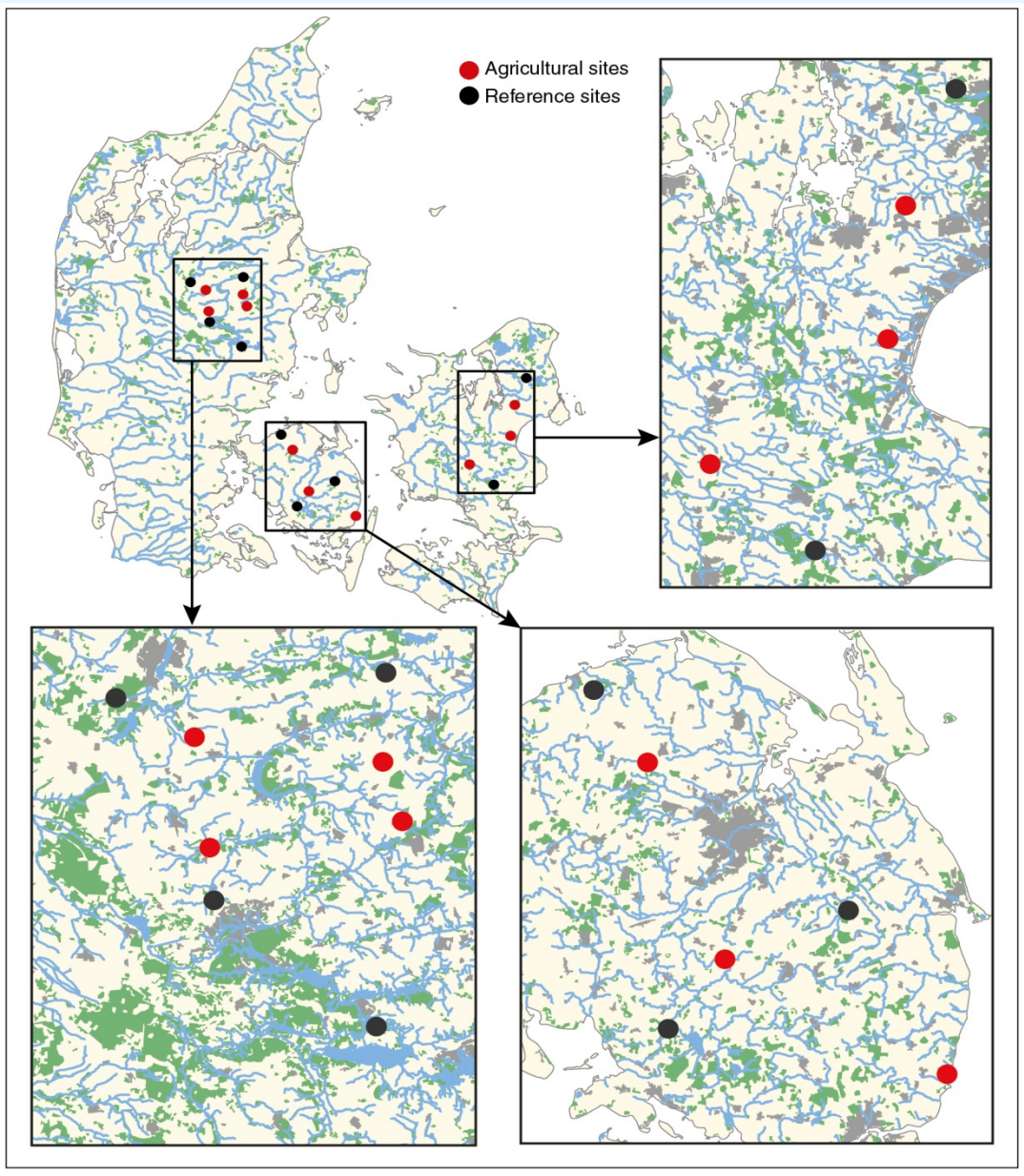
How a Com … Surface Wat … nent of

Christoph Mosch… Heinz Singer,† Ch… Piazzoli,†,‡
†Eawag, Swiss Federal …
‡Institute of Biogeoch…
§Swiss Center for App…
∥Federal Office for the…

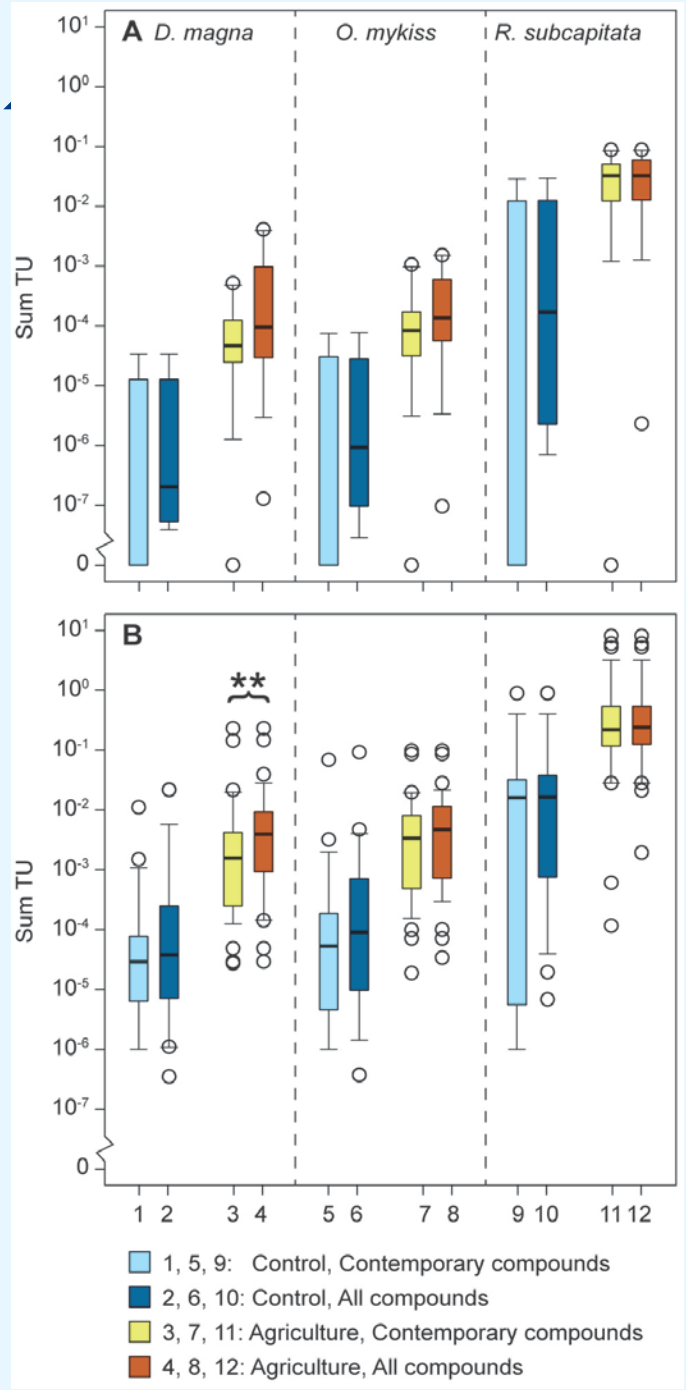


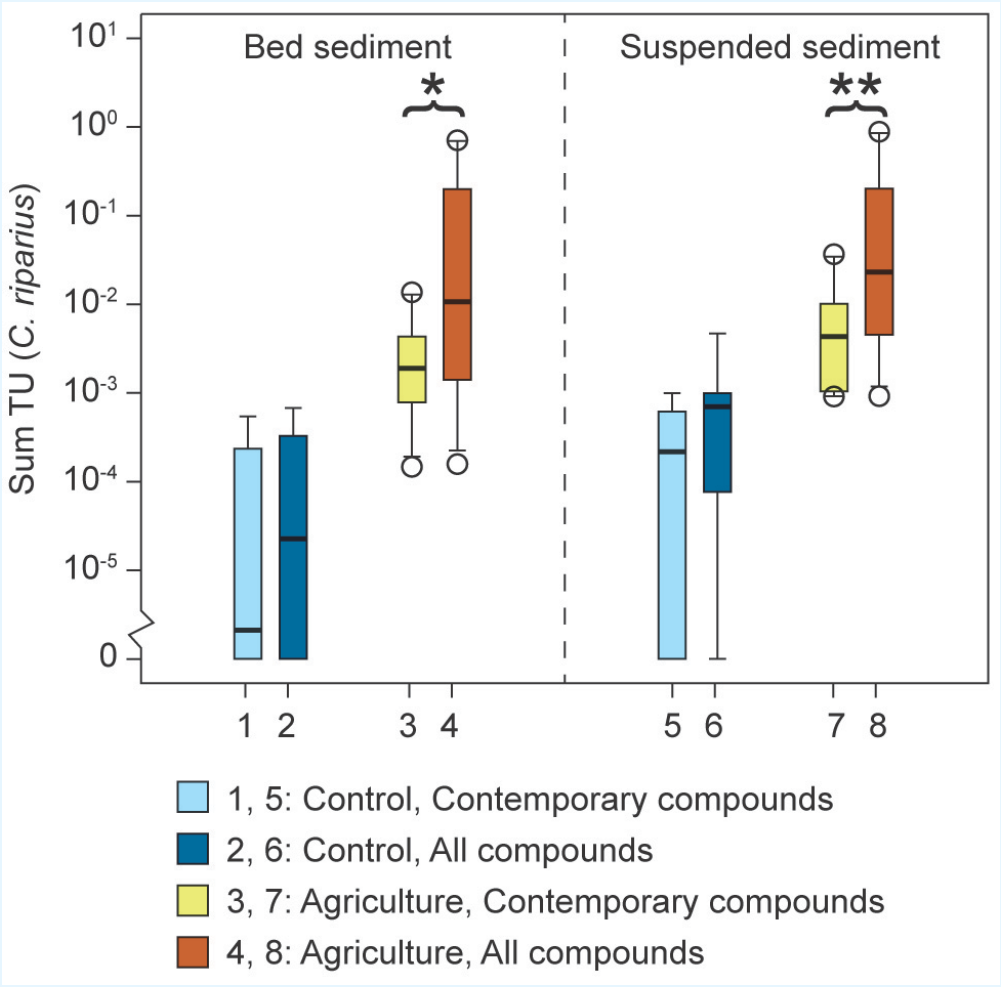
I. Danish experience

- 10 control streams + 10 agricultural streams
- Base flow samples + peak flow samples + suspended sediment + sediment
- Water samples analysed for 75 compounds
- Particle samples analysed for 59 compounds



Rasmussen et al. (in prep.)



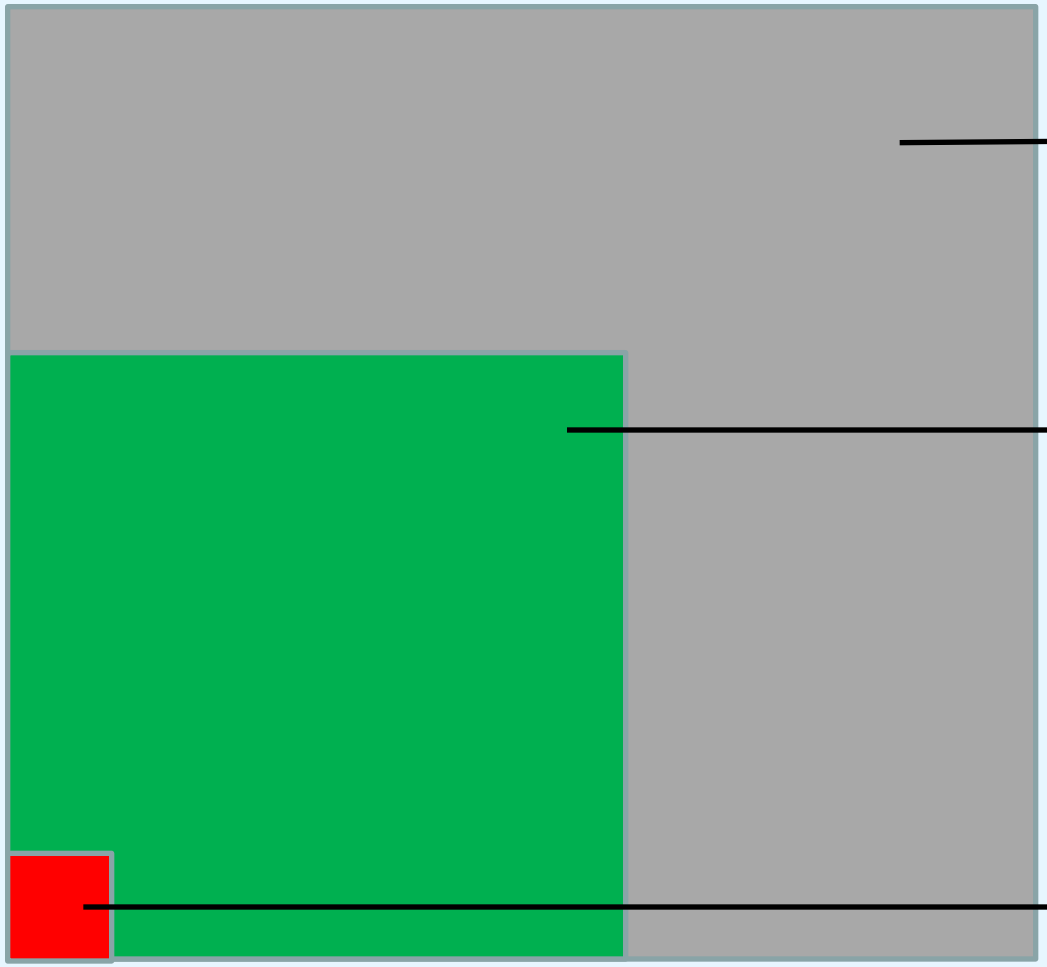


Rasmussen et al. (in prep.)

I. Summary on Exposure

- **A rather high amount of compounds need to be included in the analyses of pesticides in stream water to reach proper exposure characterisation**
- **Not only current use products should be included but also compounds used in the past could be important – especially insecticides**
- **Analysing pesticide occurrence in water and sediments with high temporal resolution would be beneficial to increase the linkage to the effect side (Data from Sweden?)**
- **How toxic is the sediment fraction – is it just historical information or still causing impact?**

II. Invertebrate communities



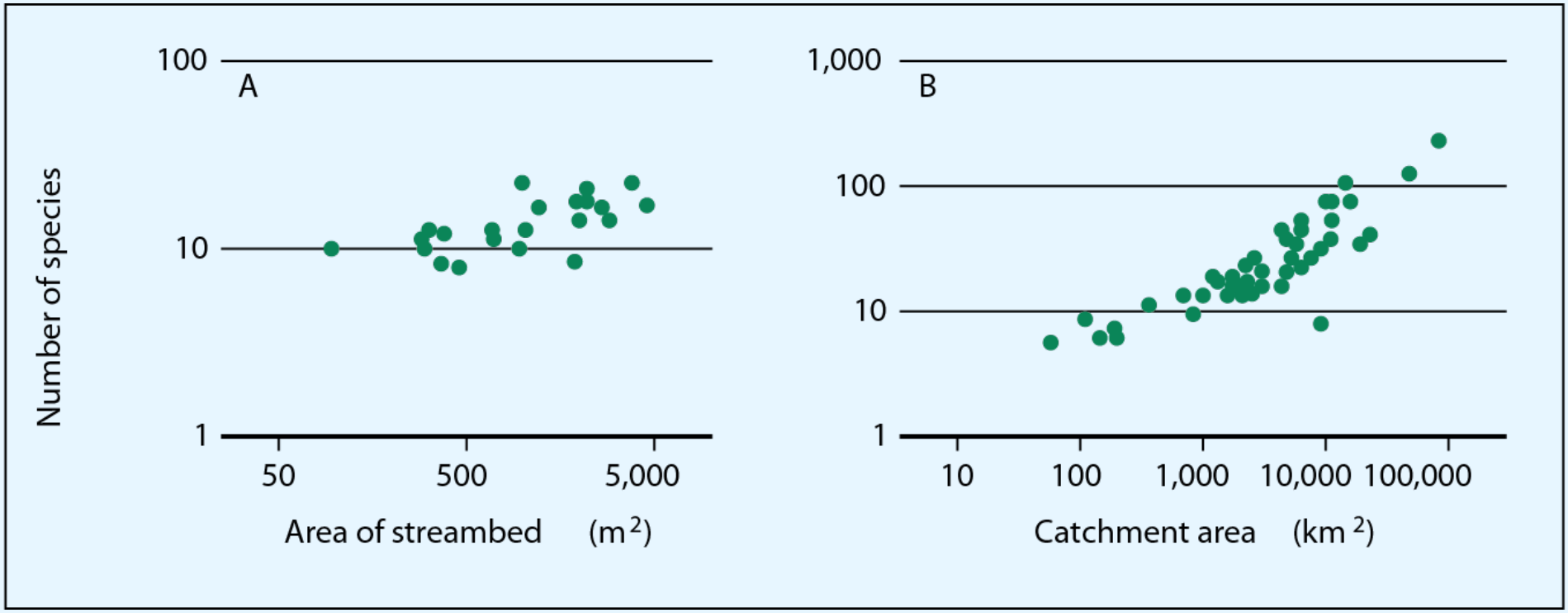
Studies on fresshwater invertebrates – including Daphnia (886 articles)

Studies on fresshwater invertebrates – without Daphnia (447 articles, 47%)

Field studies with more than one stream and community level effects considered
5 articles (0.6%)

Beketov & Liess 2012

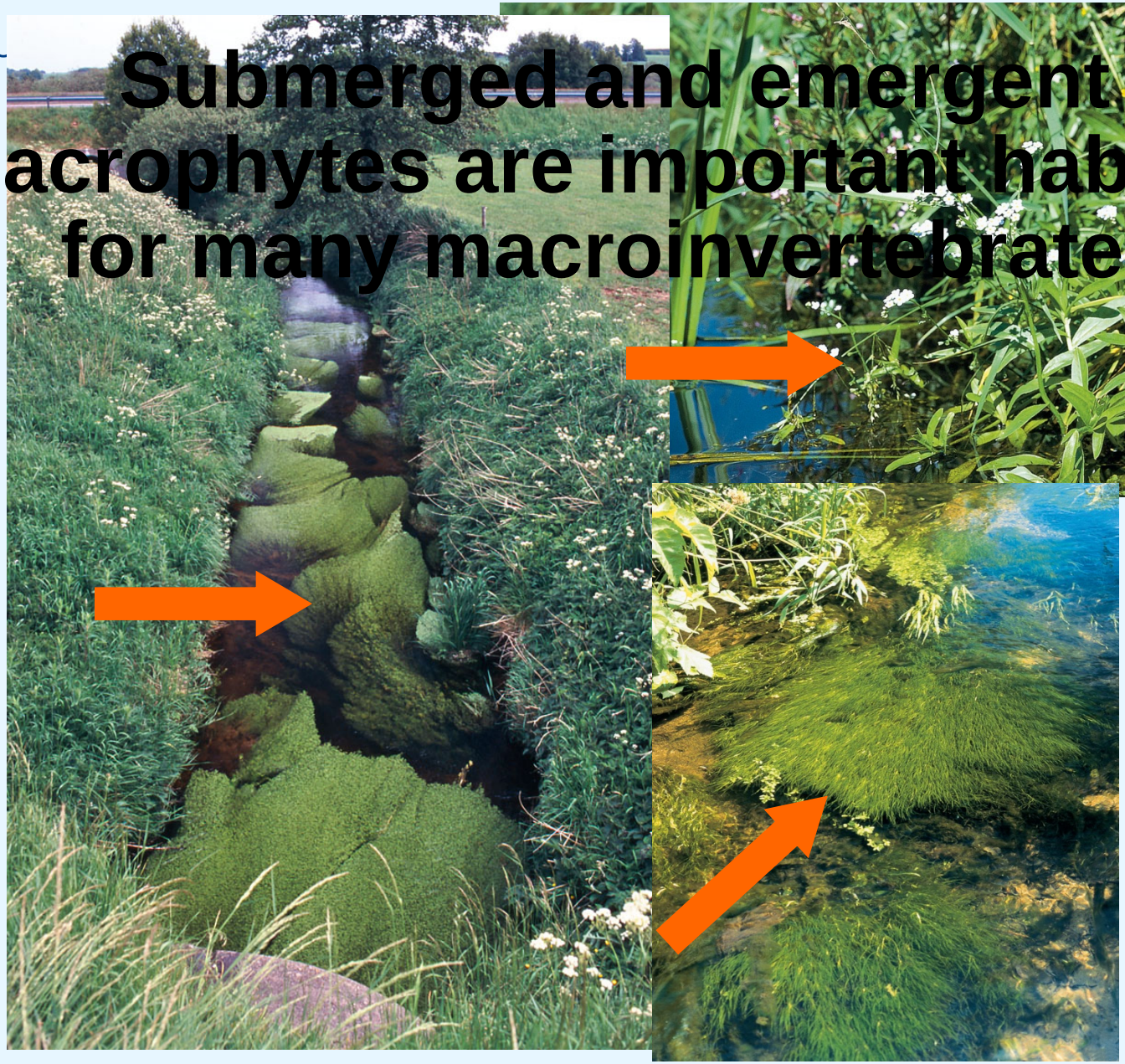
II. Invertebrates species-area relationship



Wiberg-Larsen, 2010

Important habitats for macroinvertebrates

Submerged and emergent macrophytes are important habitats for many macroinvertebrates



II. Invertebrates

- **The floodplain is important for many adult insects**

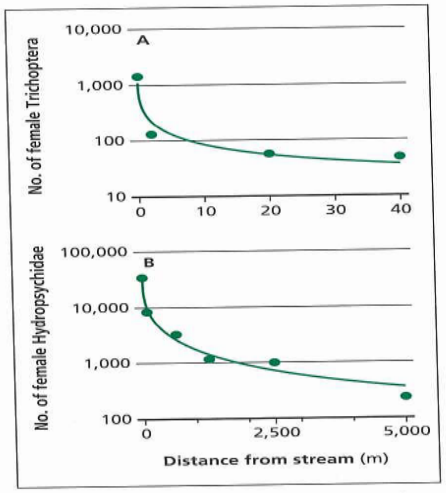


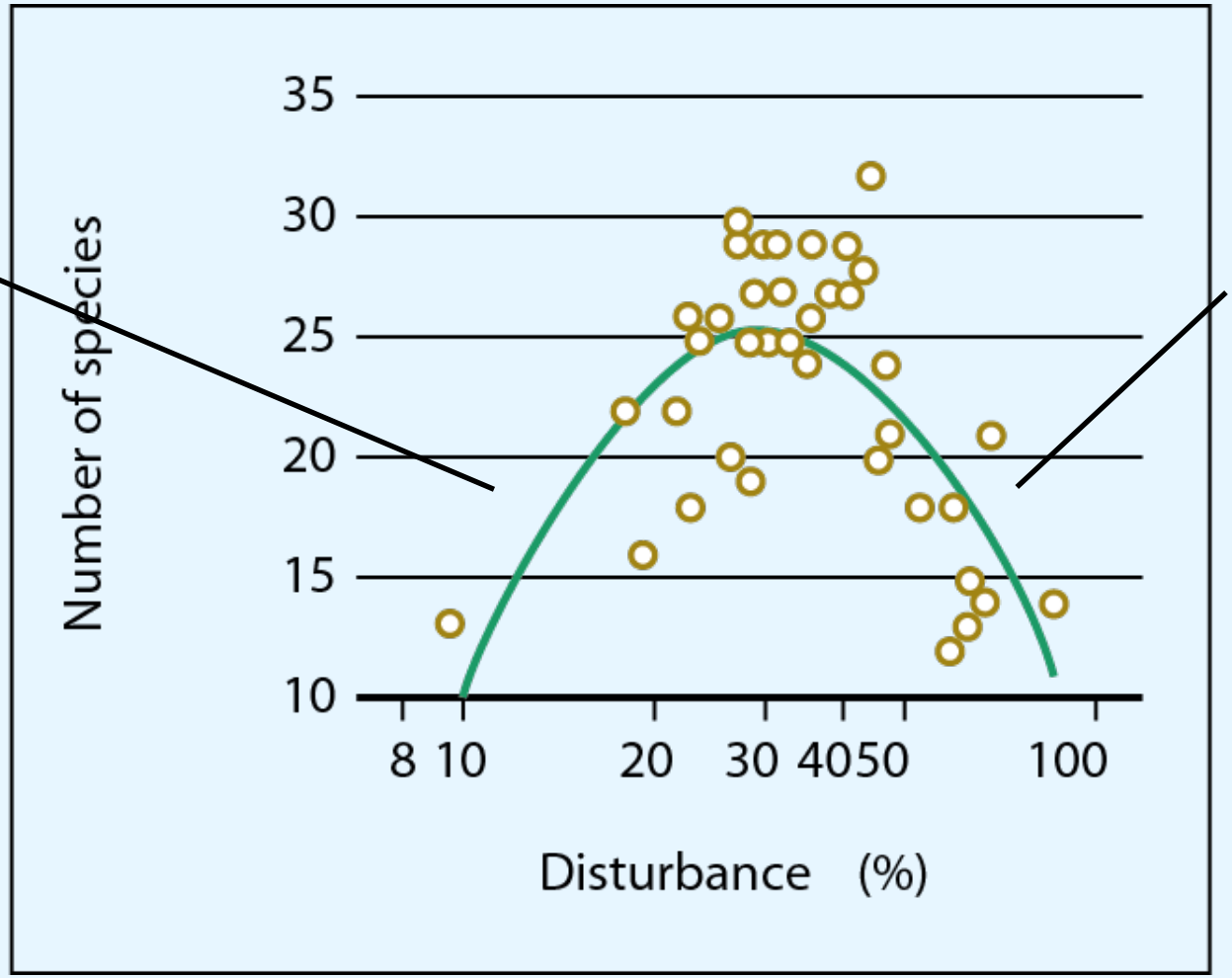
Figure 6.2 Lateral dispersal of adult caddisflies from two very different systems. A: Small forest brook on northern Funen, Denmark [14]. B: Detroit River and Lake St. Clair, Canada [16]. Note the difference in scale for individuals caught in traps, and the dispersal distance.

Many males of caddisflies perform a special flight – swarming – to attract females. Patterns and places of swarming are specific for each species.

II. The intermediate disturbance hypothesis

K-strategists

Specialists
Competition

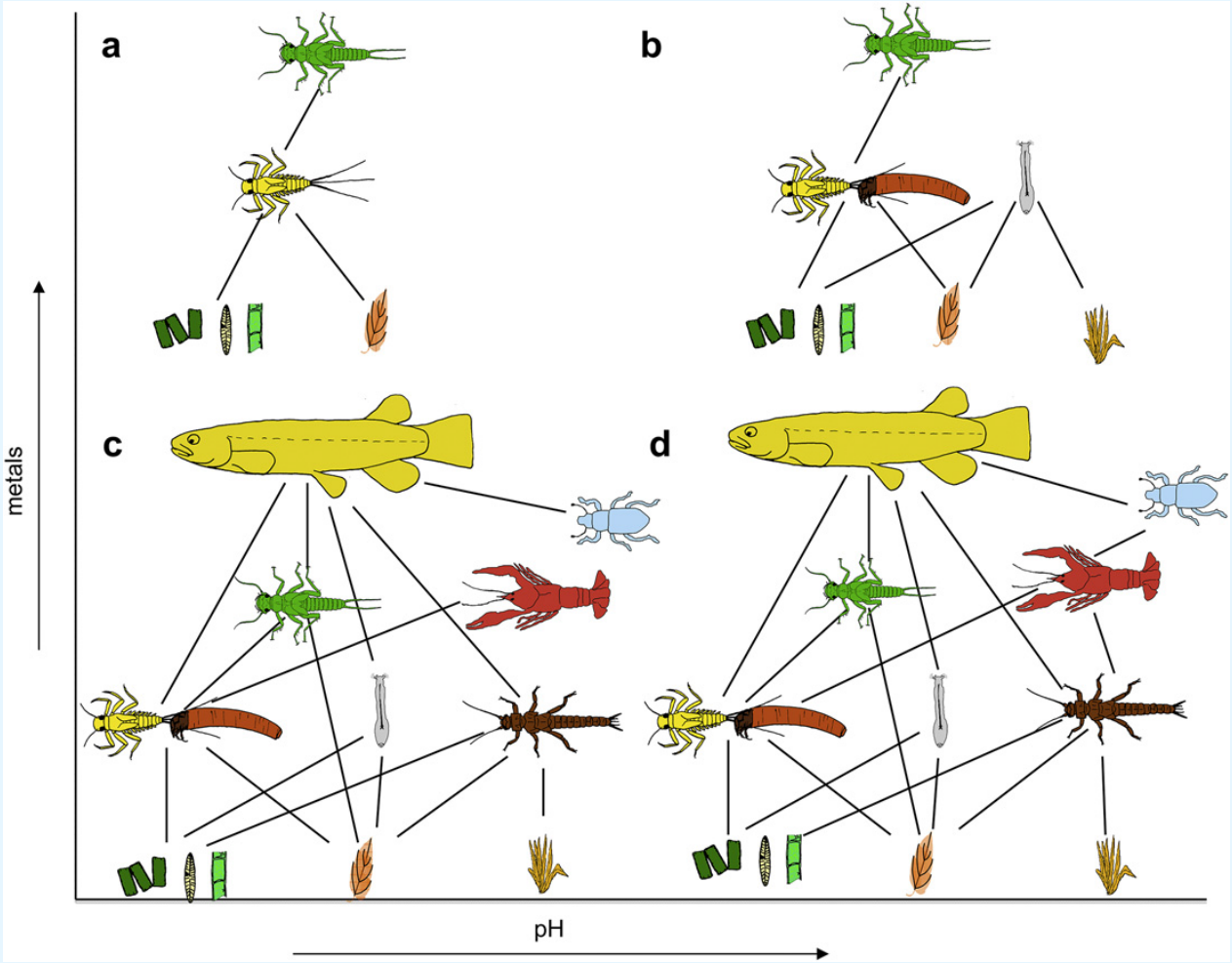


r-strategists

Generalists
Reproduction

II. Food web structure

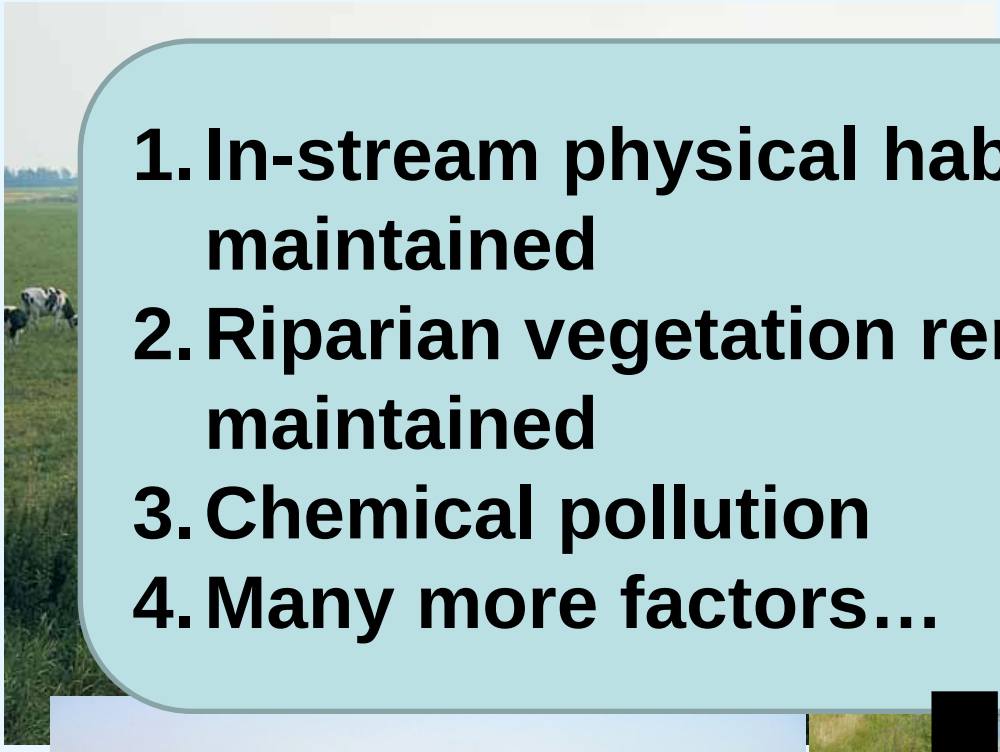
a) Mining
b) Naturally high metal
c) Naturally acidic
d) Circumneutral



Hogsden & Harding, 2013

Pesticide effects on food chains – in theory

- **Fewer links in the food chain**
- **Shorter food chains**
- **More generalist species and fewer specialists**
- **Fewer species in the food chain**
- **Elimination of species that are particularly sensitive to pesticide contamination**
- **More stable food chain (highly connected species are less vulnarable to disturbance)**



1. **In-stream physical habitats removed and maintained**
2. **Riparian vegetation removed and maintained**
3. **Chemical pollution**
4. **Many more factors…**

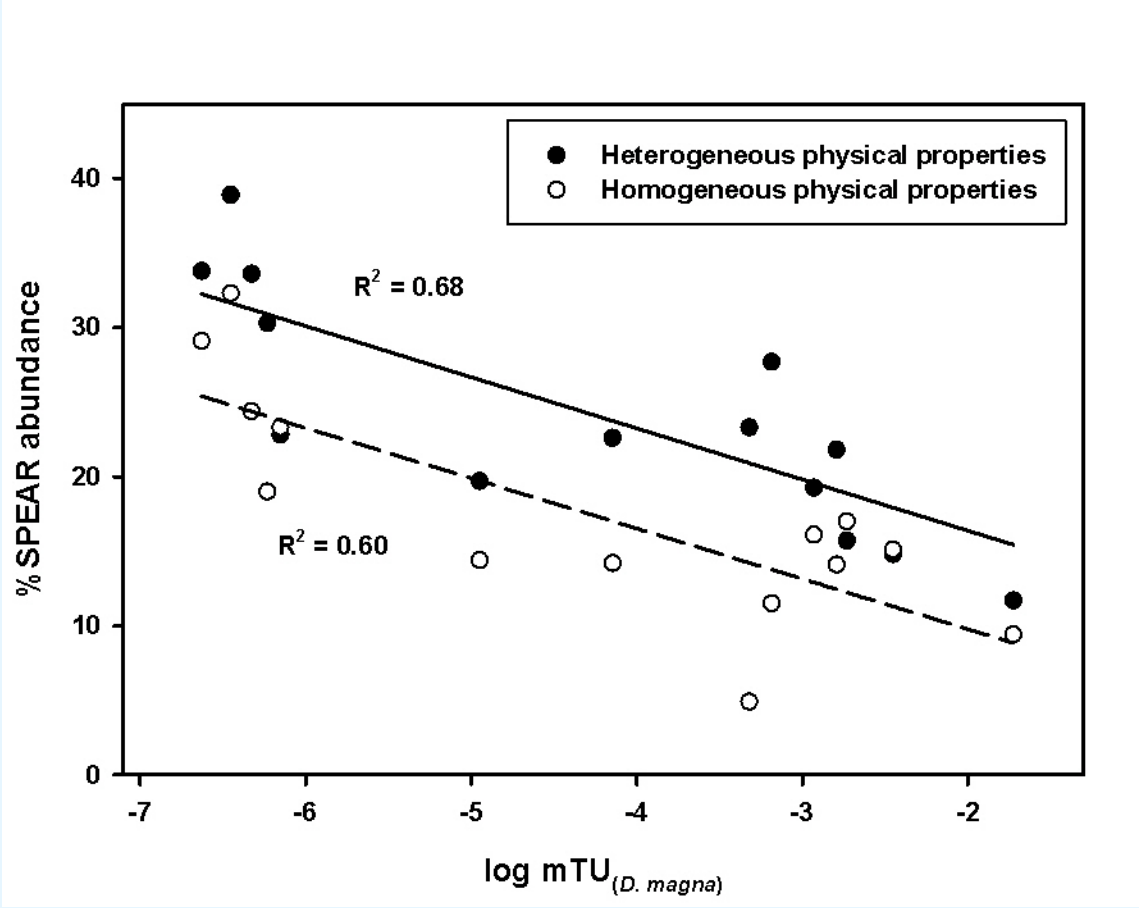
Selection for generalist traits
Shorter food chain with fewer links and fewer species

II. Danish experience

Downstream

Upstream

%SPEAR abundance is lower in streams that are physically hampered



Rasmussen et al. 2012, *Environ. Poll.* **164**, 142-149

Few SPEcies At Risk have strong influence on the final SPEAR score

Taxa	Physical indicator group	P-value
Asellus aquaticus.	Homogeneous	0.048
Pisidium sp.	Homogeneous	0.077
Tanytarsini	Homogeneous	0.087
Baetis rhodani	Heterogeneous	0.063
Dicranota sp.	Heterogeneous	0.034
Dugesia gonocephala	Heterogeneous	0.070
Leuctra fusca	Heterogeneous	0.083
Limnius volckmari	Heterogeneous	0.070
Silo spp.	Heterogeneous	0.010
Simuliidae	Heterogeneous	0.013

Rasmussen et al. 2012, *Environ. Poll.* **164**, 142-149

So … how to increase the ecological effect signal of pesticide exposure?

- **Generalist traits respond (increase in abundance) to all types of recurring disturbances by humans**
- **SPEAR differentiates from other work on traits by implementing species sensitivities to pesticides**
- **More clear interpretations of pesticide effects in the field could be obtained by increasing the data quality of species sensitivities to pesticides**
  - **Can we establish some general rules and relationships that explain which factors (morphological) render species sensitive to pesticides?**


Thank you for
your attention!