The use of SPEAR and TOXIC UNITS to link ecological status to chemical pollution

Peter C. von der Ohe & Werner Brack

http://www.modelkey.org

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Major challenge

Directive 2000/60/EC of the European parliament and of the council establishing a framework for community action in the field of water policy

aims to achieve until 2015

good ecological and chemical status

➔ Relation between Chemical Exposure and Ecological Effects

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Assessment of Ecological Status

Biological Quality Element (BQE) based indicators

(fish, algae, plants and macroinvertebrates)

AQEM Software PERLODES uses three modules

1. Organic pollution
2. Acidification
3. General degradation (multimetric indicators recommended!)
   - Morphological degradation
   - Pesticides
   - Hormon equivalent compounds

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SPEAR indicator*

Classification as SPecies At Risk (SPEAR):

1. high relative sensitivity $S_{organic}$ (based on acute LC50)
2. long generation time, low reproductivity

* M. Liess, von der Ohe P.C. 2005. Predicting Effects of Pesticides on Invertebrate Communities in Streams. *Environ. Toxicol. Chem.* **24:** 954-965.

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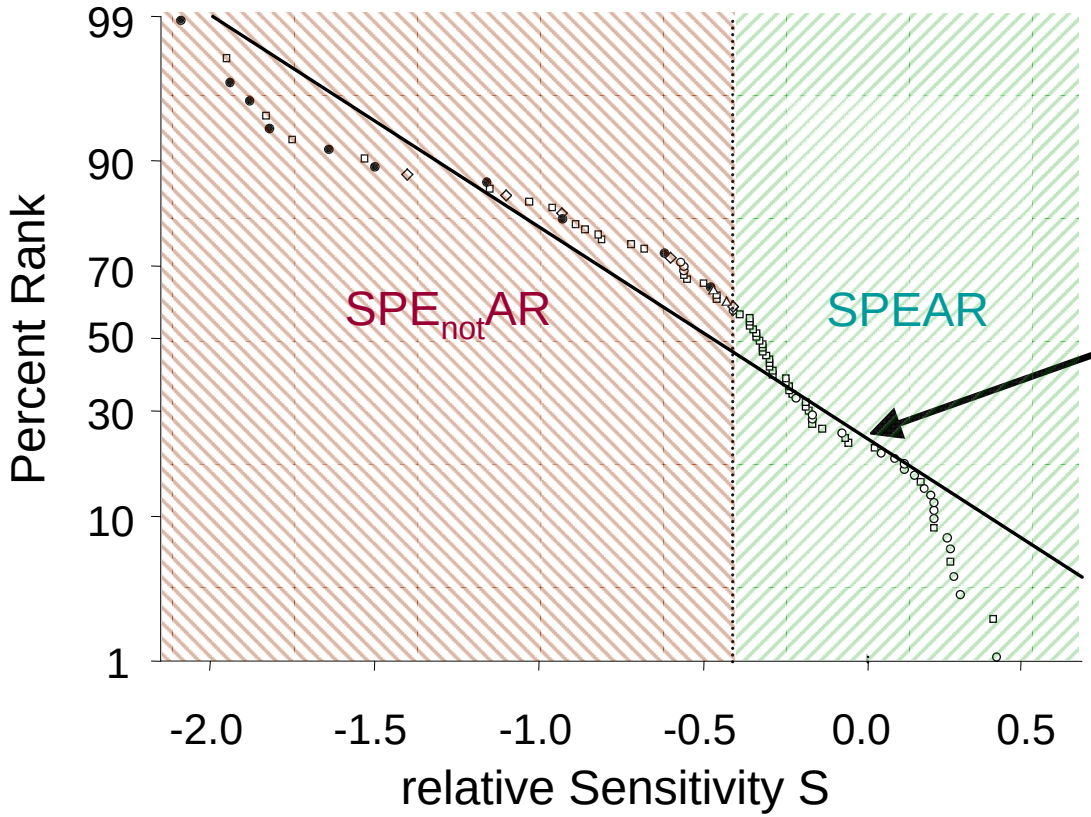
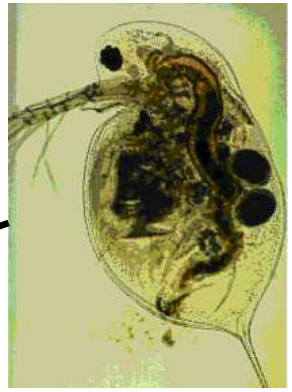
SPEAR - relative Sensitivity S*

➔ whole community could be assessed!





Daphnia magna

* P.C. von der Ohe & Liess M. 2004. Relative Sensitivity Distribution of Aquatic Invertebrates to Organic and Metal Compounds. *Environ. Toxicol. Chem.* **23:** 150-156.

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Example: reference community




relative Sensitivity S





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Example: reference community

at risk

not at risk



number of broods







➔ SPEAR ~ 50%

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Example: disturbed community






relative Sensitivity S




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Example: disturbed community

at risk

not at risk

generation time

number of broods

➔ SPEAR ~ 10%

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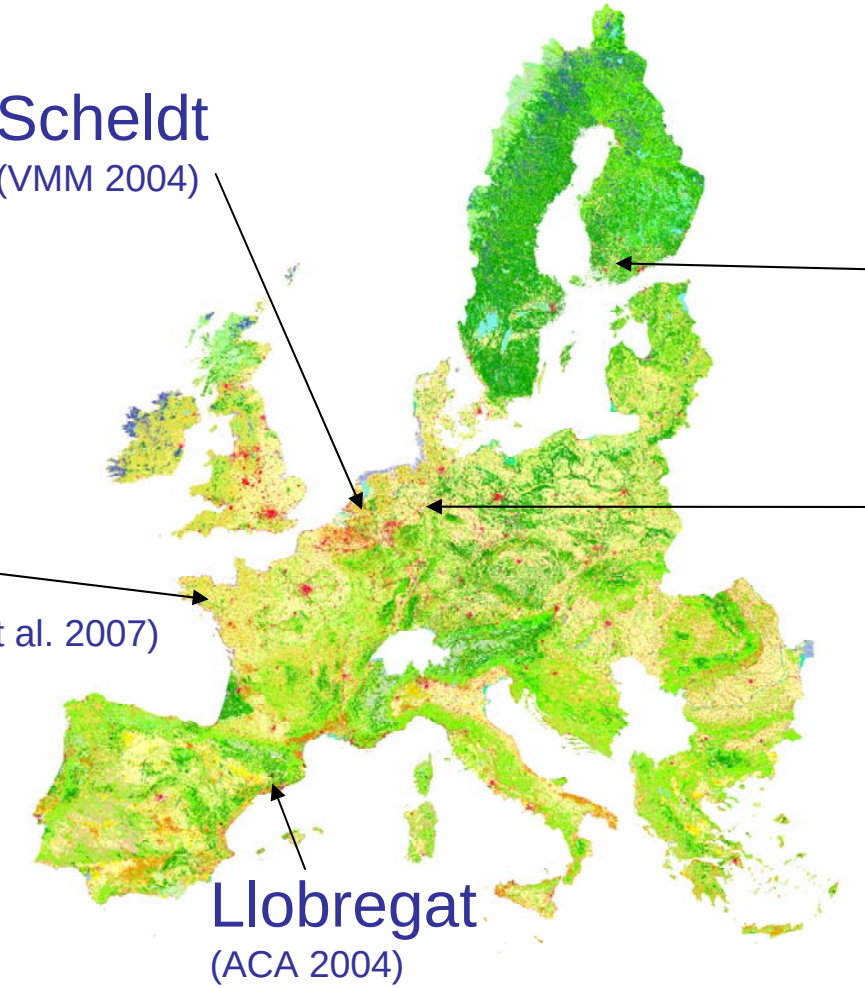
Reference conditions in Europe*



Scheldt
(VMM 2004)

Porvoonjoki
(R.B. Schäfer et al. 2007)

Weser
(NLWK 2000)

Scorff
(R.B. Schäfer et al. 2007)

Llobregat
(ACA 2004)

* P.C. von der Ohe et al. 2007. Water quality indices across Europe - a comparison of the good ecological status of five river basins. *J. Environ. Monit.* **24:** 954-965.

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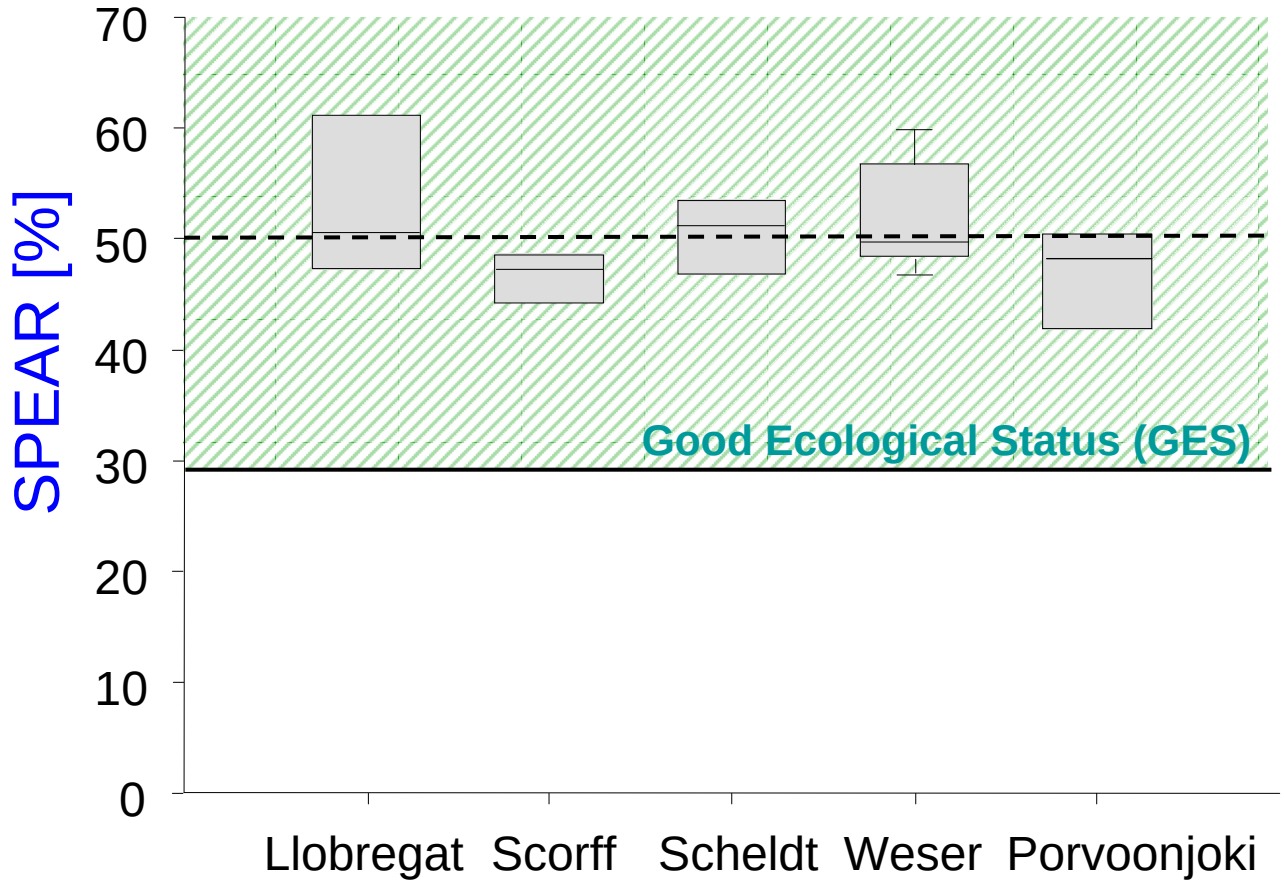

* P.C. von der Ohe et al. 2007. Water quality indices across Europe - a comparison of the good ecological status of five river basins. *J. Environ. Monit.* **24:** 954-965.

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Toxic Stress: Example pesticides

- EC 1992-2004: annual pesticide usage between 200.000 t and 250.000 t (Eurostat 2007)
- Deliberate output into the environment

© Schäfer 2008

➔ **Effects expected!**

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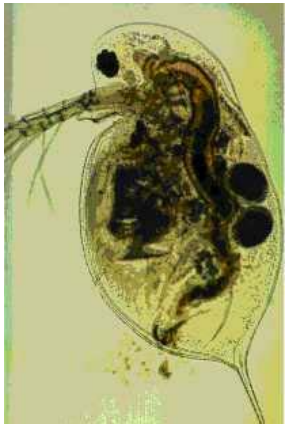
Quantification of Toxic Stress

$$\textit{Toxic Units}_{\textit{Daphnia magna}} = \log \sum_{i=1}^{n} \frac{C_i}{LC50_i}$$



with

C_i = measured concentration

$LC50_i$ = lethal concentration (48h)

N = number of compounds

➔ Correlations with biotic indicators

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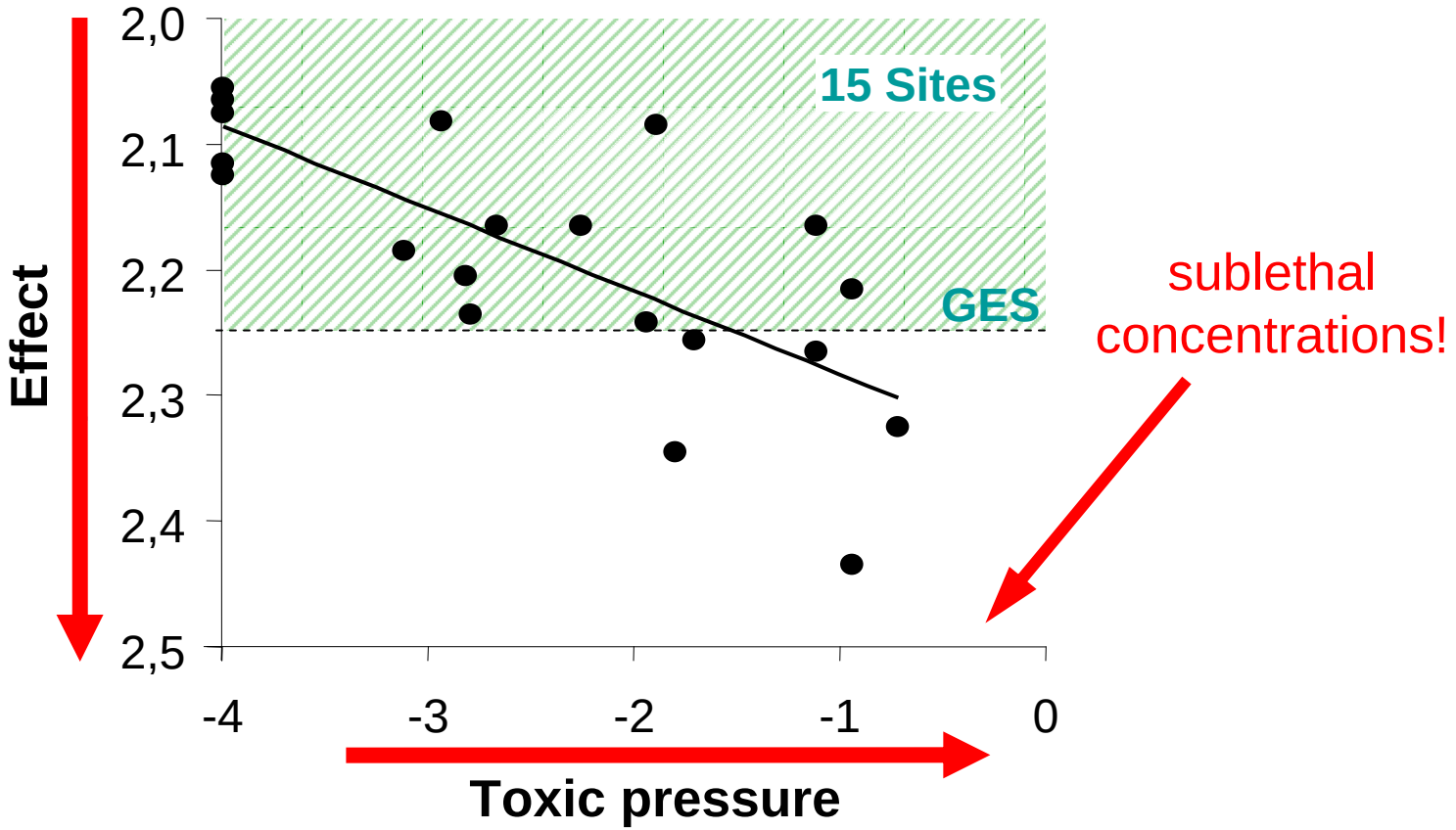
Saprobic Index vs. Toxic Units



* M. Liess, von der Ohe P.C. 2005. Predicting Effects of Pesticides on Invertebrate Communities in Streams. *Environ. Toxicol. Chem.* **24:** 954-965.

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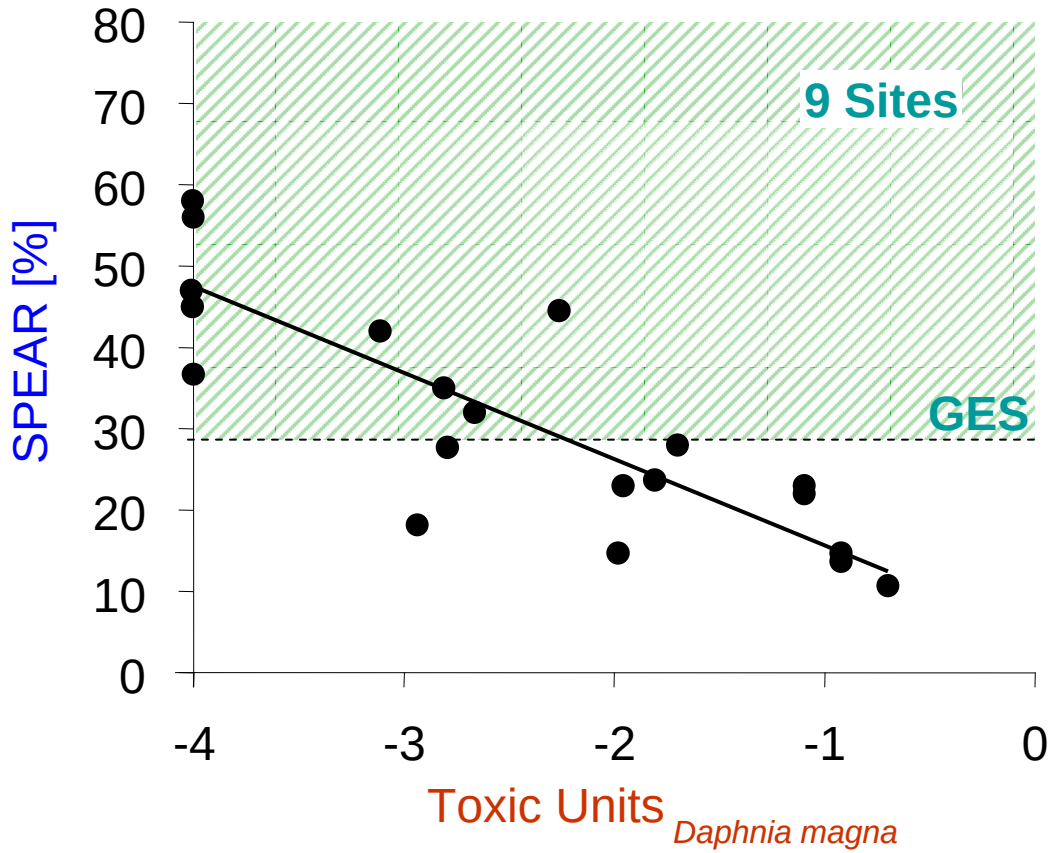
SPEAR vs. Toxic Units



* M. Liess, von der Ohe P.C. 2005. Predicting Effects of Pesticides on Invertebrate Communities in Streams. *Environ. Toxicol. Chem.* **24:** 954-965.

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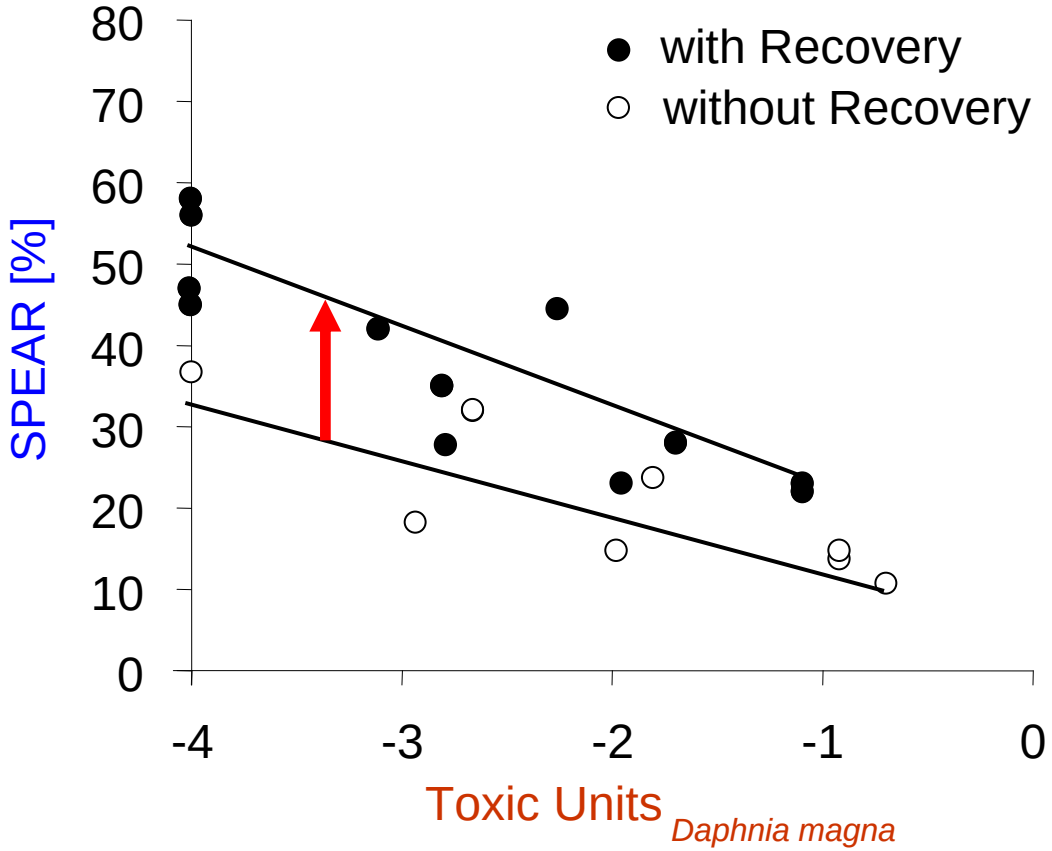
Effects of Recovery



* M. Liess, von der Ohe P.C. 2005. Predicting Effects of Pesticides on Invertebrate Communities in Streams. *Environ. Toxicol. Chem.* **24:** 954-965.

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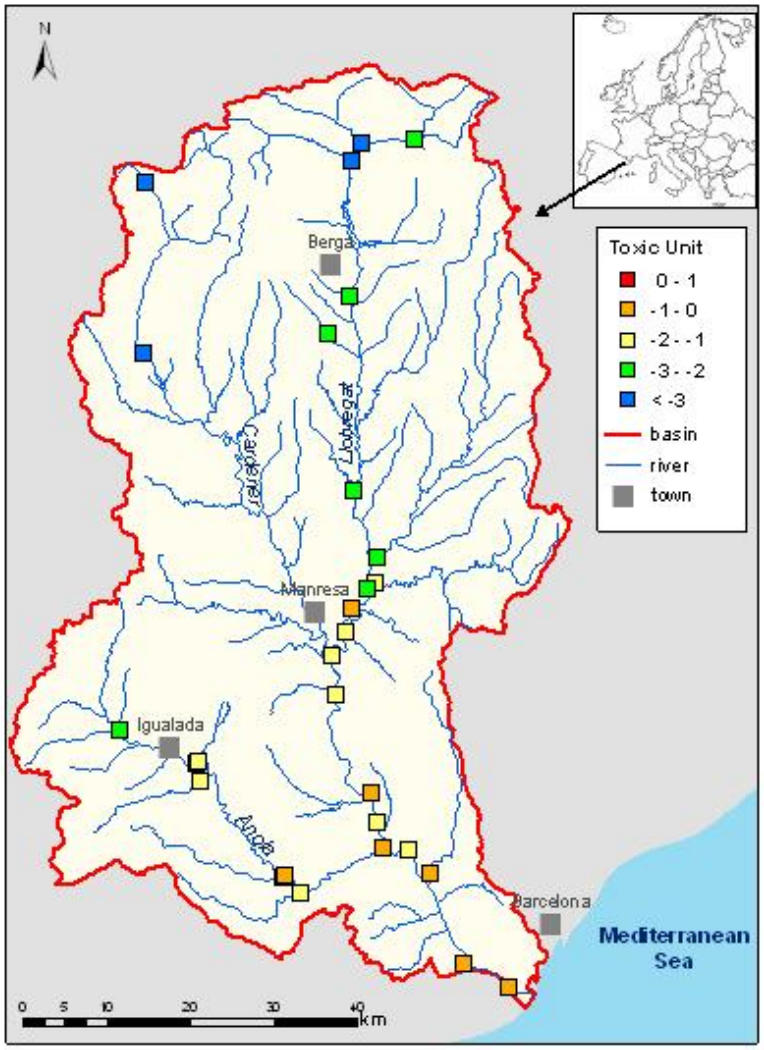
BASIN: monitoring data evaluation



30 monitoring sites in the Llobregat River Basin

Figure 1: Toxic Units *D. magna*

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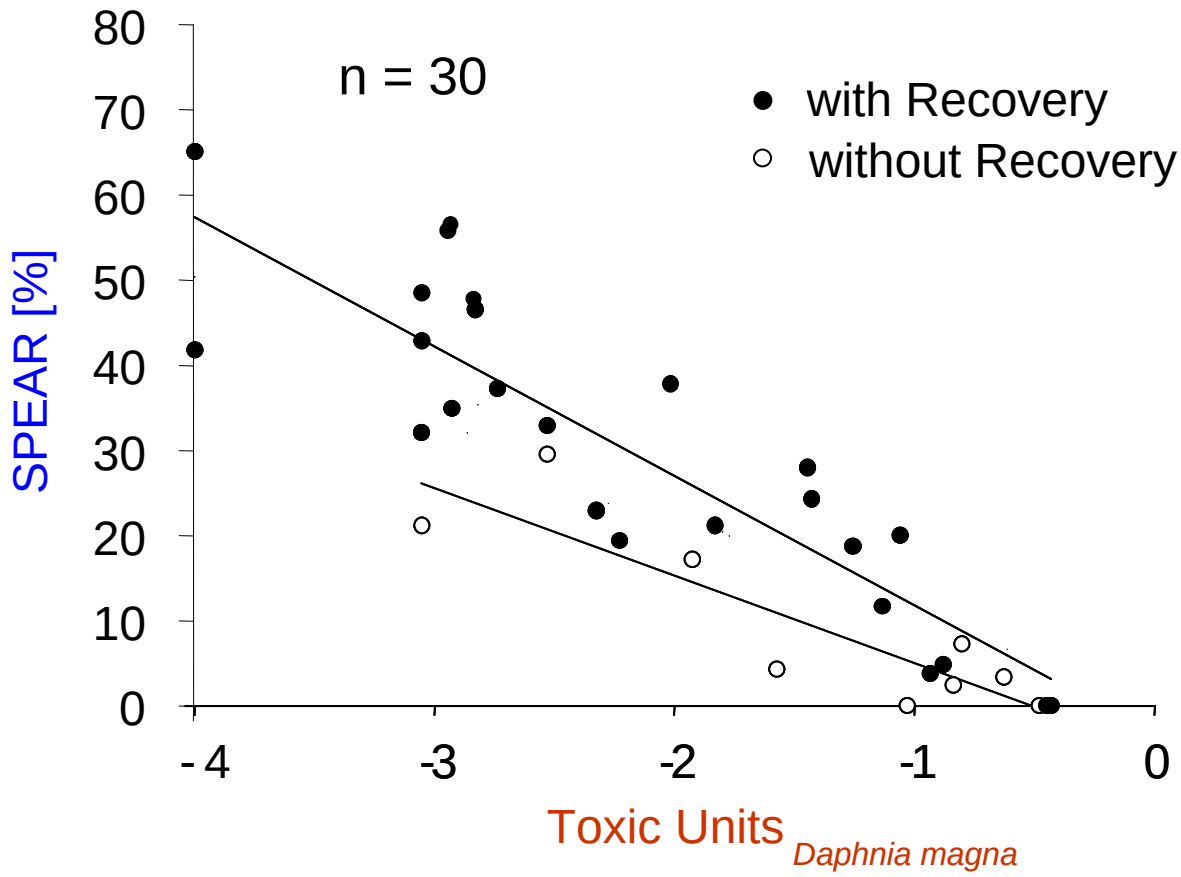
Case-study Llobregat



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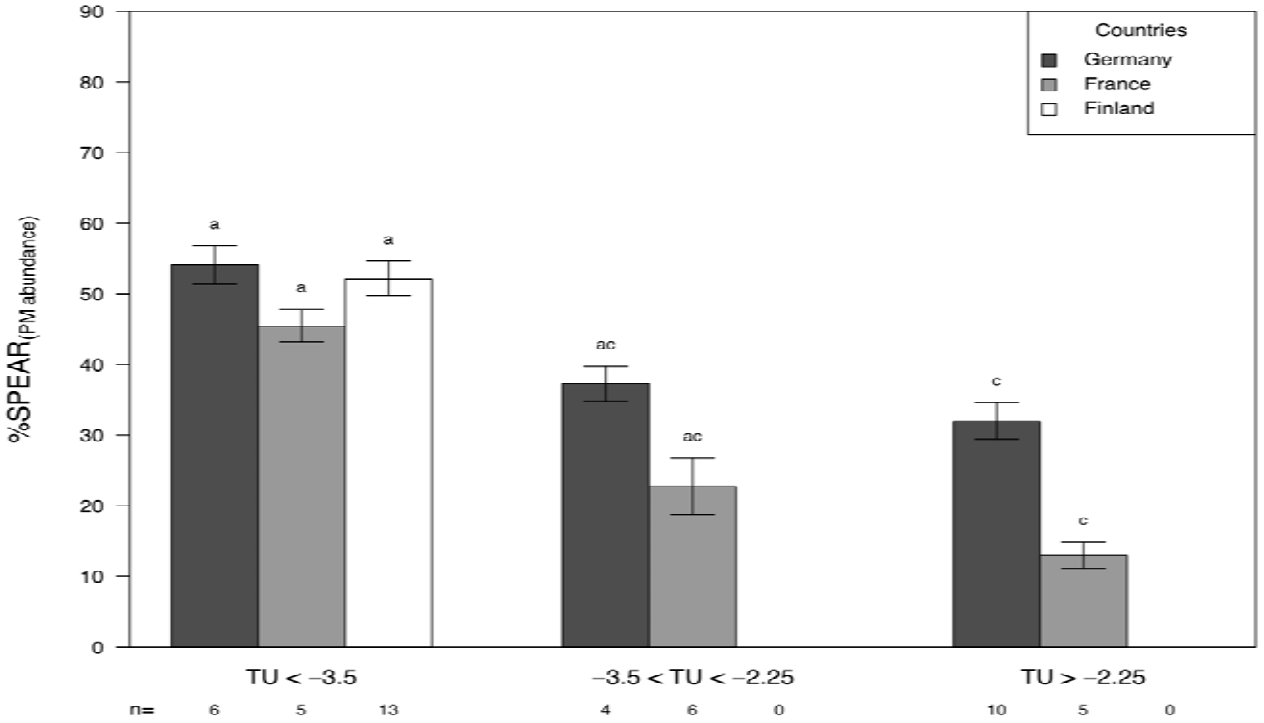
Comparison France – Finland*

no linear modell for %SPEAR

best-fit modell: Toxic Units and Recovery Potential



* R.B. Schäfer et al. 2007. Effects of pesticides on community structure and ecosystem functions in agricultural streams of three biogeog. regions in Europe. *Sci. Tot. Environ*. **382:** 272-285.

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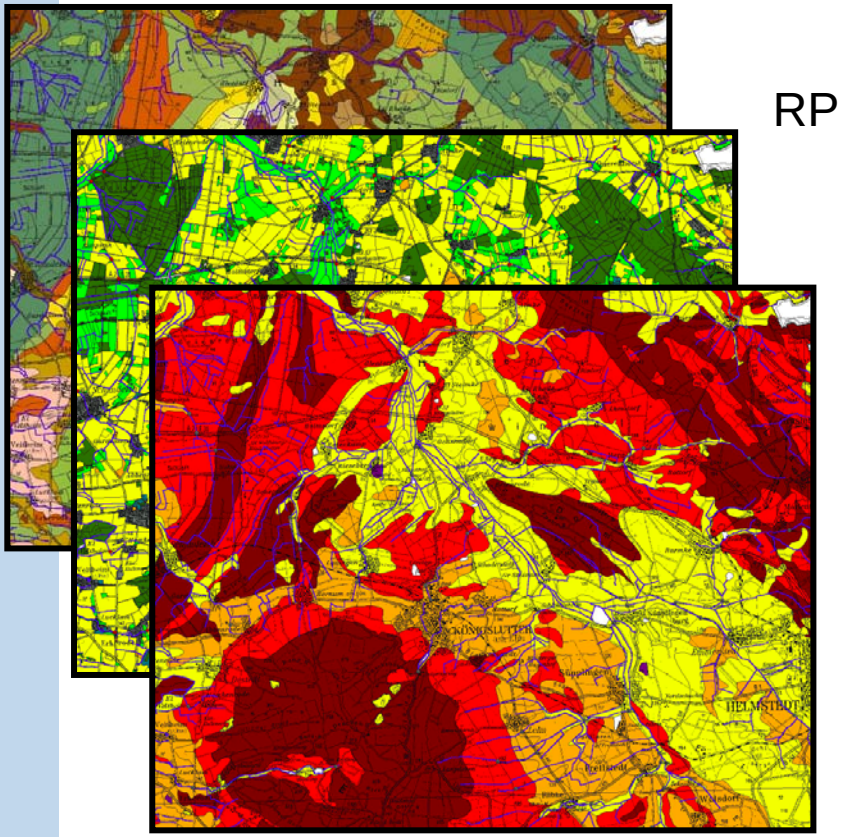
Modelled Run-off Potential (RP*)



Soil Type
Land-cover
Slope © Berenzen

$$RP = \frac{f(P)}{P} \sum_{i=1}^{n} A_i \cdot f(s_i) \cdot \left(1 - \frac{I_i}{100}\right) \cdot \frac{100}{1 + toc_i}$$

Precipitation
Time

Pesticide-Freight → **Run-off Potential**

* Schriever, C.A., von der Ohe, P.C. and M. Liess. 2005. An indicator of the potential aquatic exposure caused by pesticide runoff. *Chemosphere* **68**: 2161-2171.

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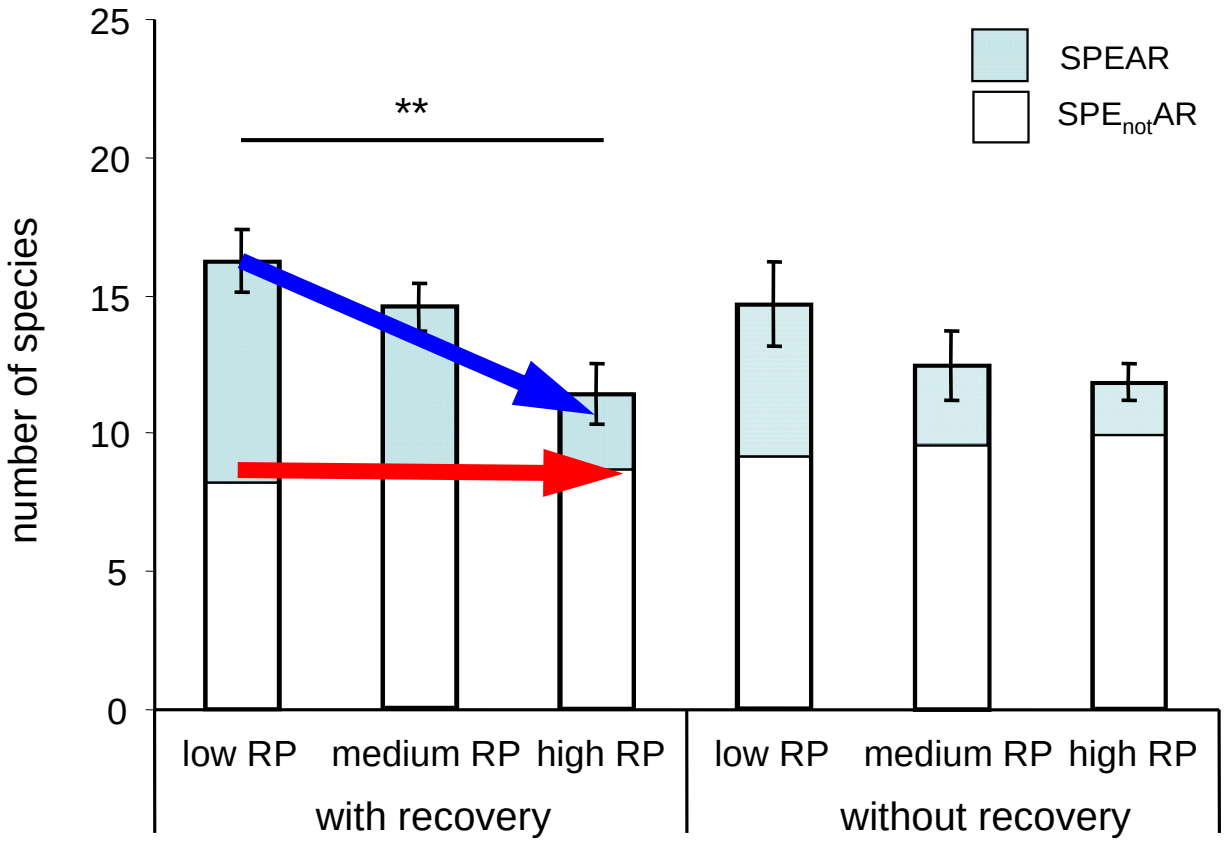
Effects on biodiversity



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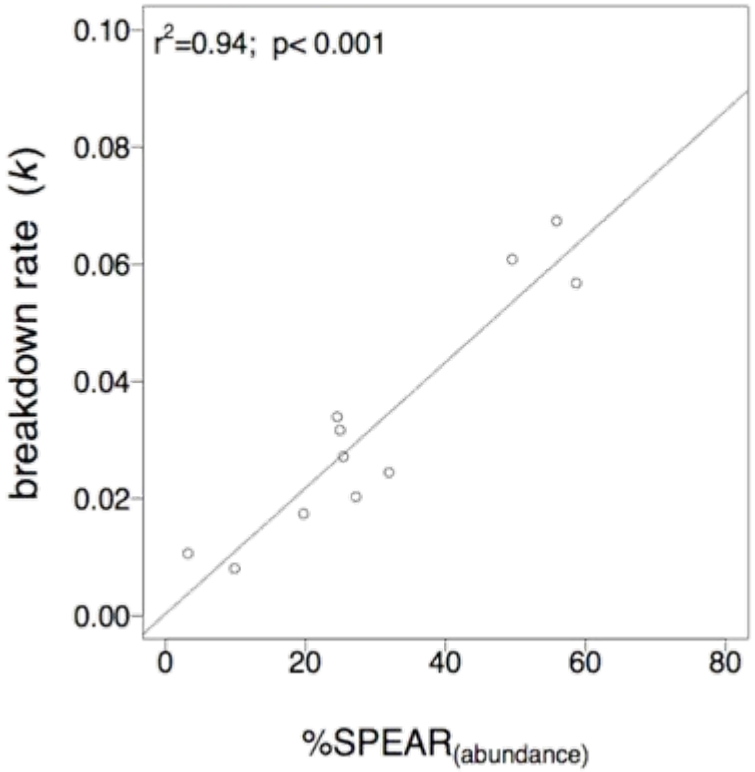
Effects on Ecosystem functions*

Breakdown rate with Temperature (r^2 = 0.88, p<0.01)

Breakdown rate with Toxic Units and Recovery (r^2= 0.44 , p<0.01)

Why SPEAR as explanatory variable?

➔ 60 to 70% of the shredder species are classified as SPEAR!



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Summary

- SPEAR showed strong correlation to Toxic Units
- Reduction of SPEAR species might be linked to biodiversity loss and effects ecosystem services

➔ Need for stressor specific biological indicators (toxicity, nutrification or morphological degradation

➔ Need for BQE specific indicators of toxicity to detect effects (Toxic Units instead of EQS)

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Outlook

Toxic Units for Algae and Fish available (predicted LC50 available from QSAR)

➔ Need for toxicity specific biological indicators for Algae and Fish

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Thank You

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