

Statistical Eco(-toxico)logy

Improving the Utilisation of Data for
Environmental Risk Assessment

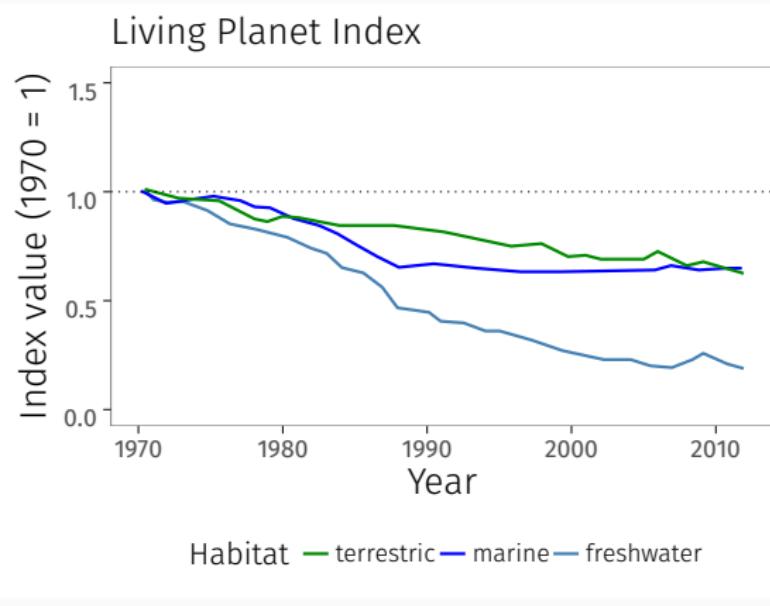
Eduard Szöcs

25th January 2017

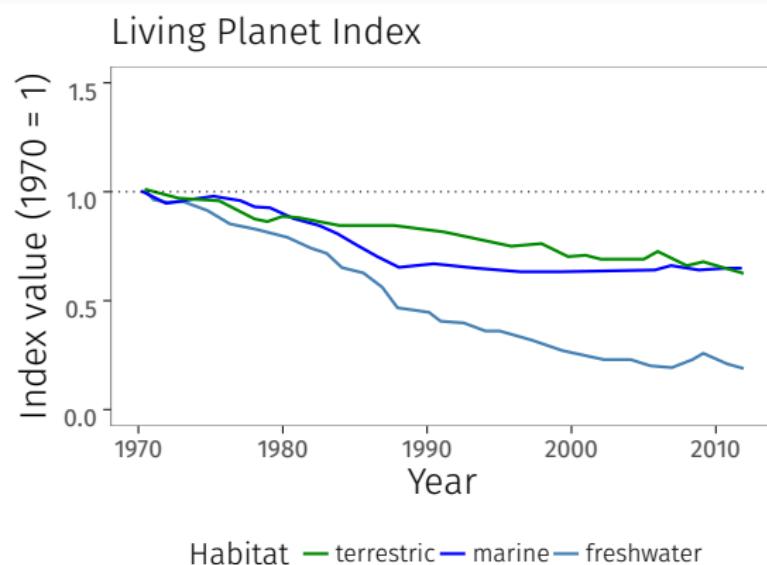
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2. Improving Statistics in ERA
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Freshwater biodiversity is strongly declining



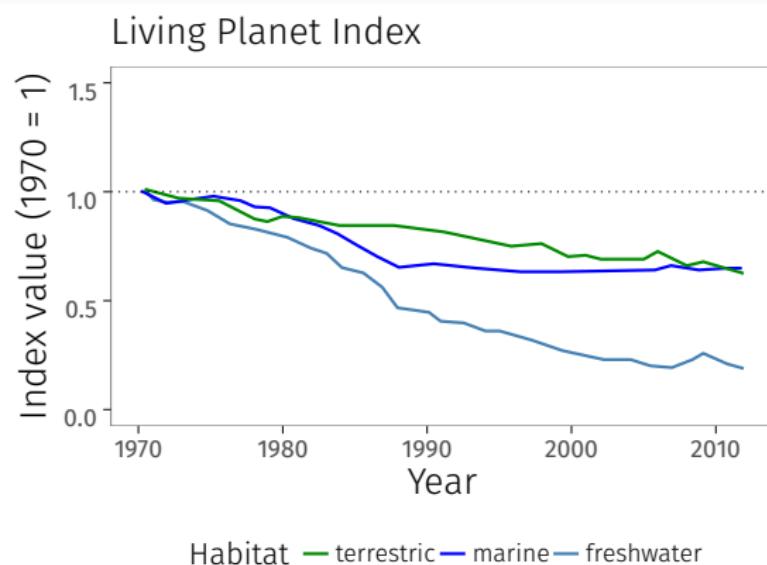
Freshwater biodiversity is strongly declining



Reasons

- Habitat loss
- Overexploitation
- Pollution
- Invasive species

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Environmental Risk Assessment and Environmental Monitoring

Environmental Risk Assessment and Monitoring

Plant Protection Products
Regulation 1107/2009

Water Framework Directive
2000/60/EC

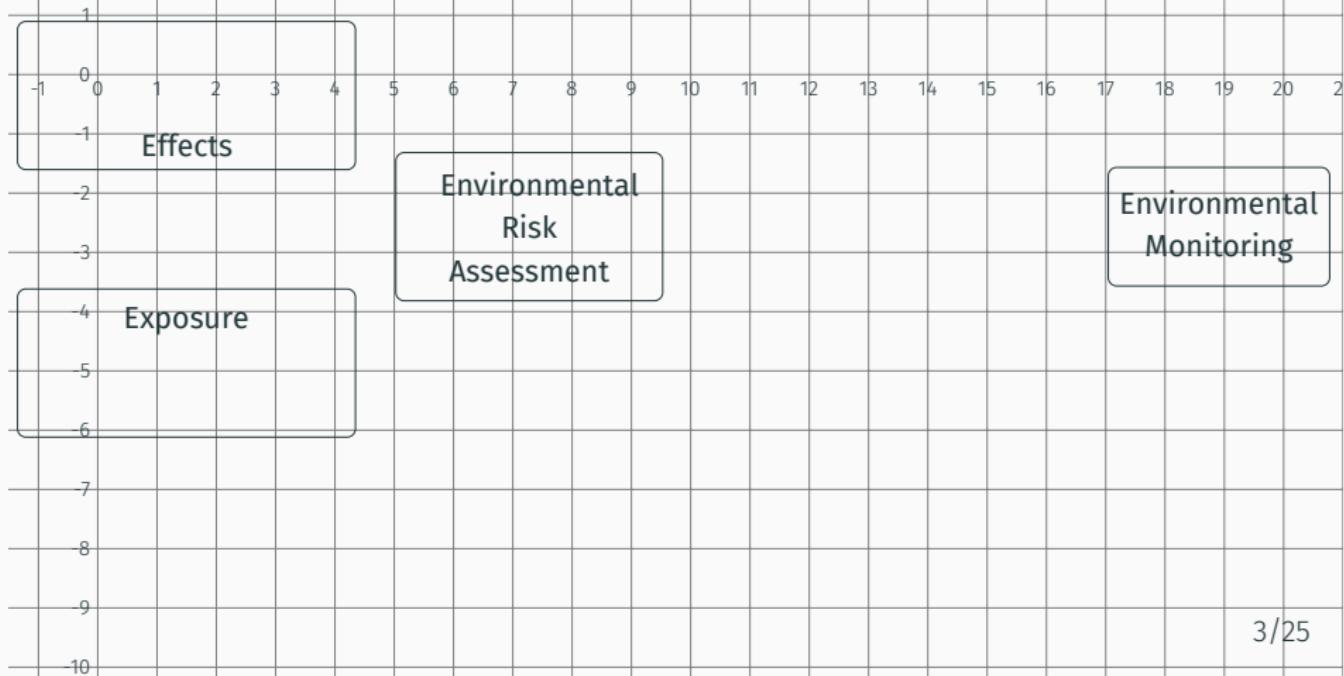
Environmental
Risk
Assessment

Environmental
Monitoring

Environmental Risk Assessment and Monitoring

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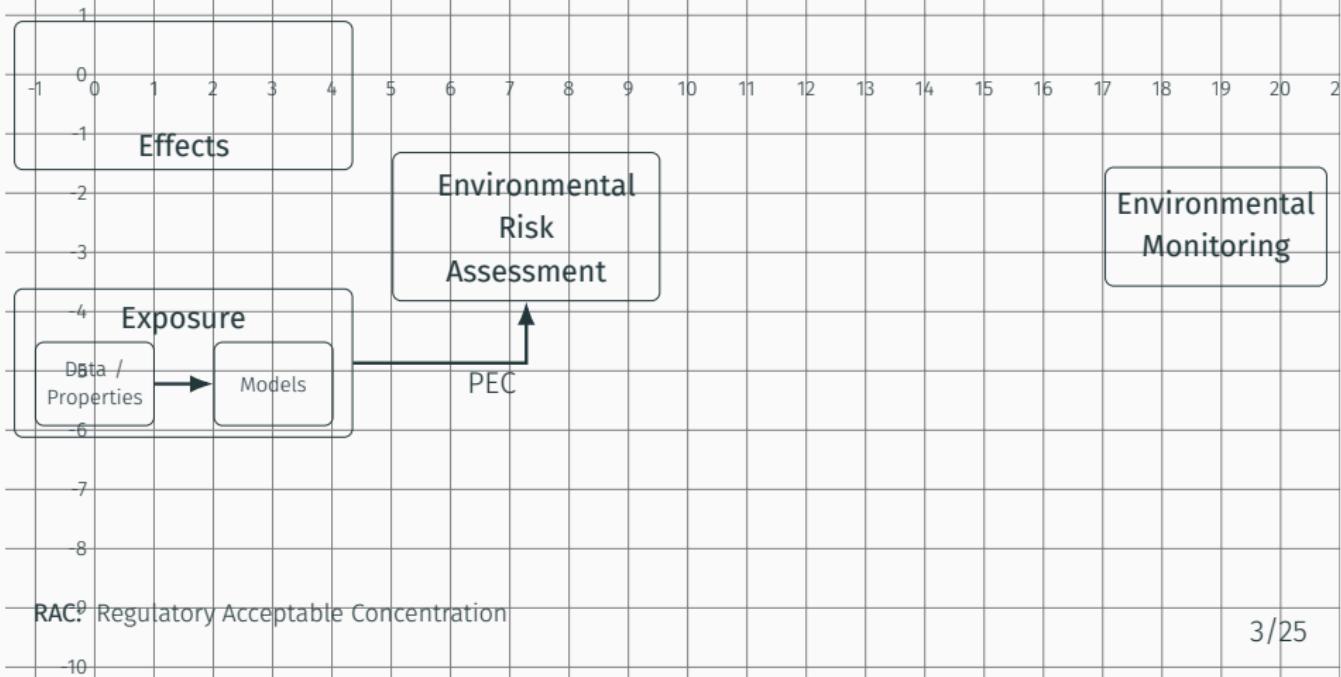
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Environmental Risk Assessment and Monitoring

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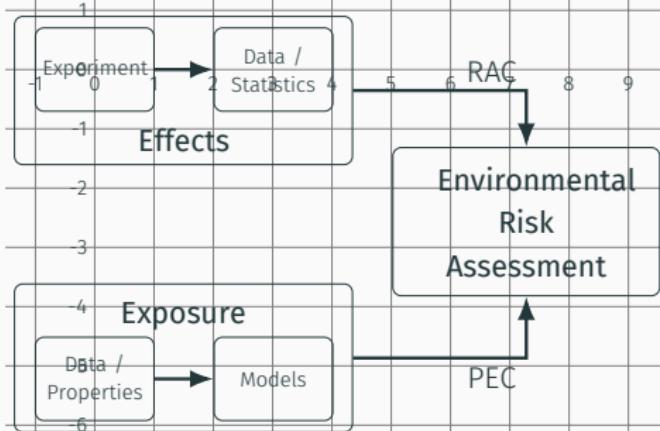
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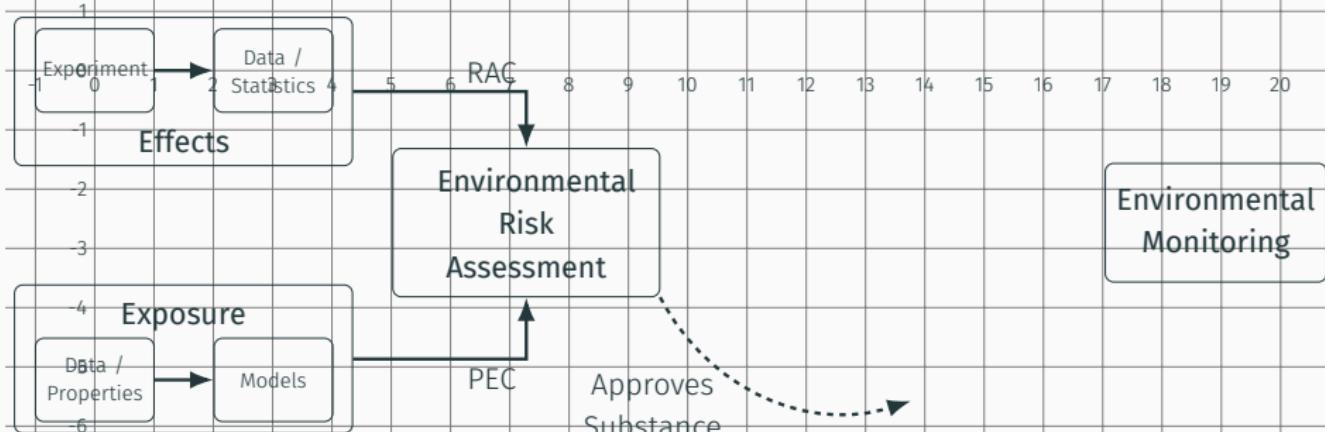
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PEC: Predicted Environmental Concentration

Environmental Risk Assessment and Monitoring

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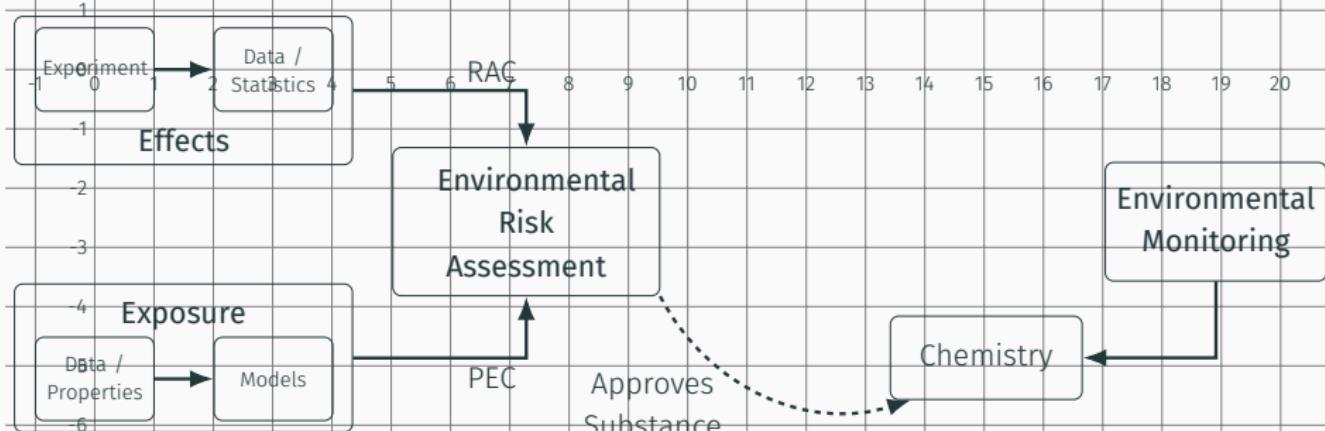
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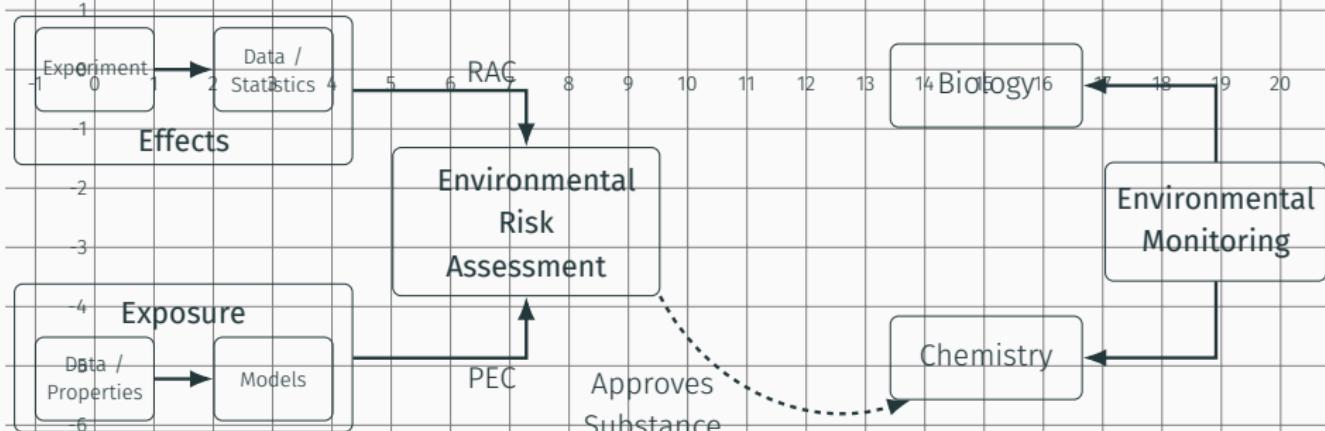
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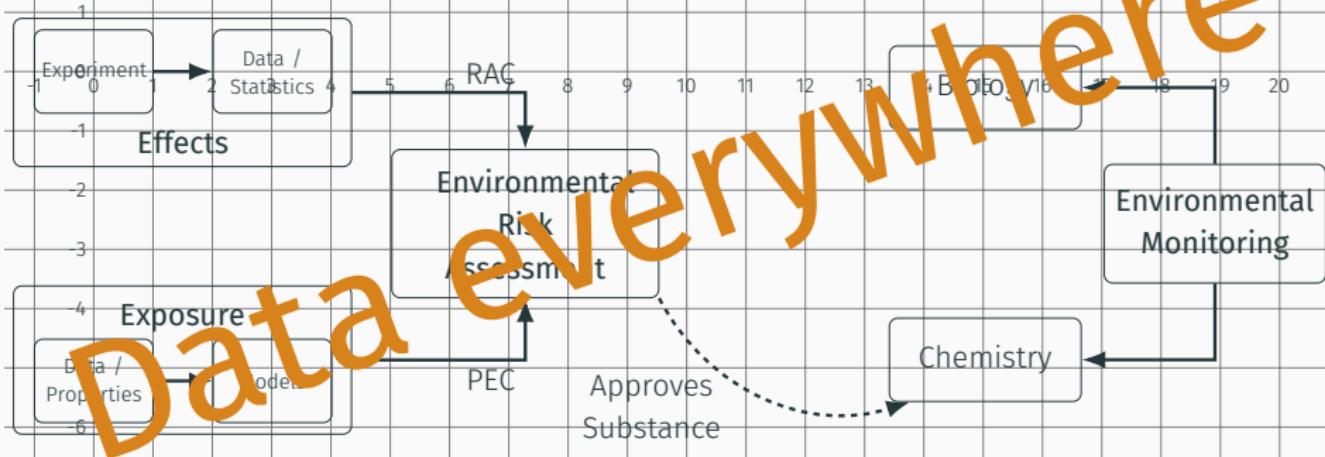
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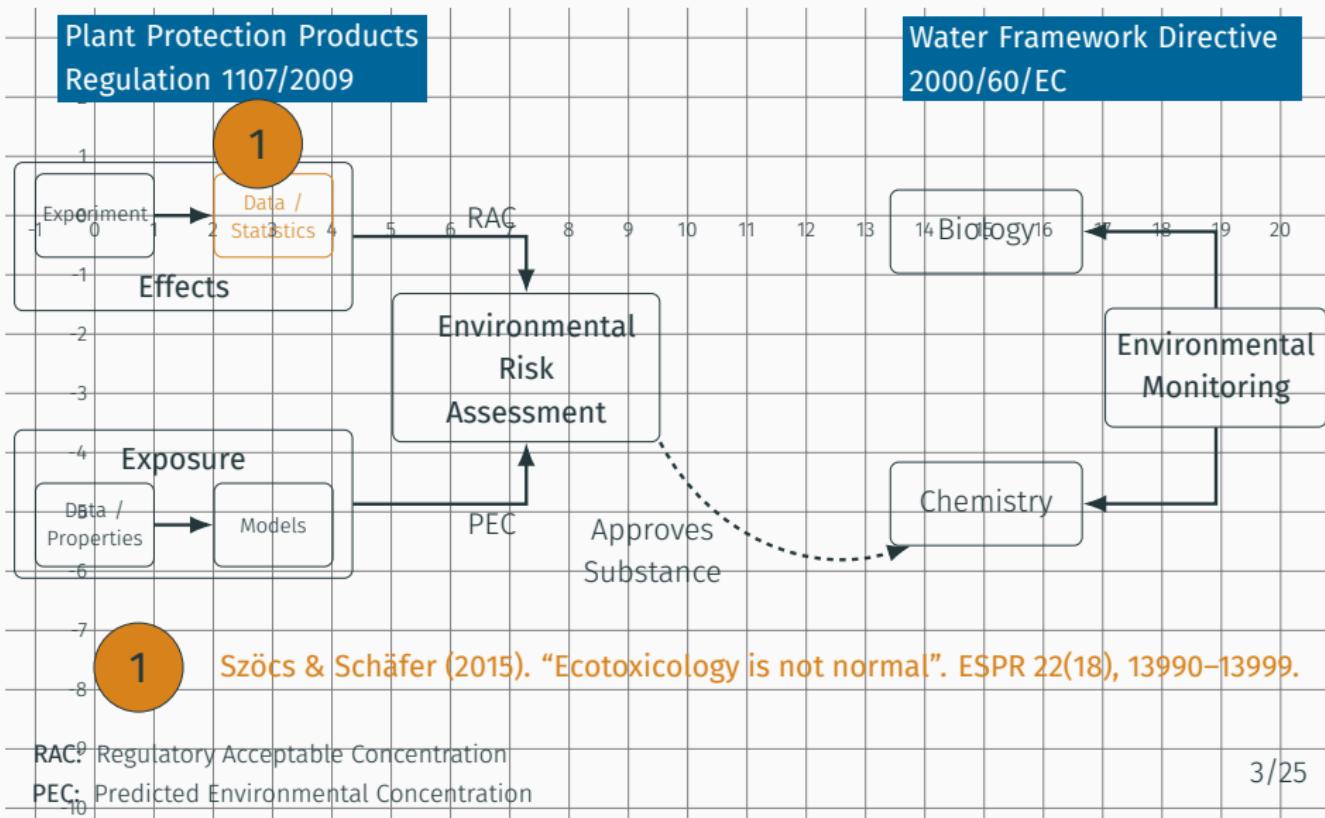
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Improving Statistics in ERA



Improving Statistics in ERA

Experiments in Effect Assessment



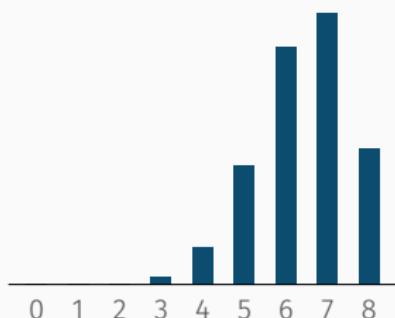
- Daphnia Test
- " x out of n survived"

Experiments in Effect Assessment

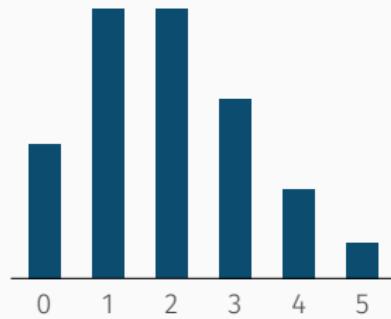


- Daphnia Test
- " x out of n survived"
- Mesocosm
- "*number of animals*"

Ecotoxicology is not normal

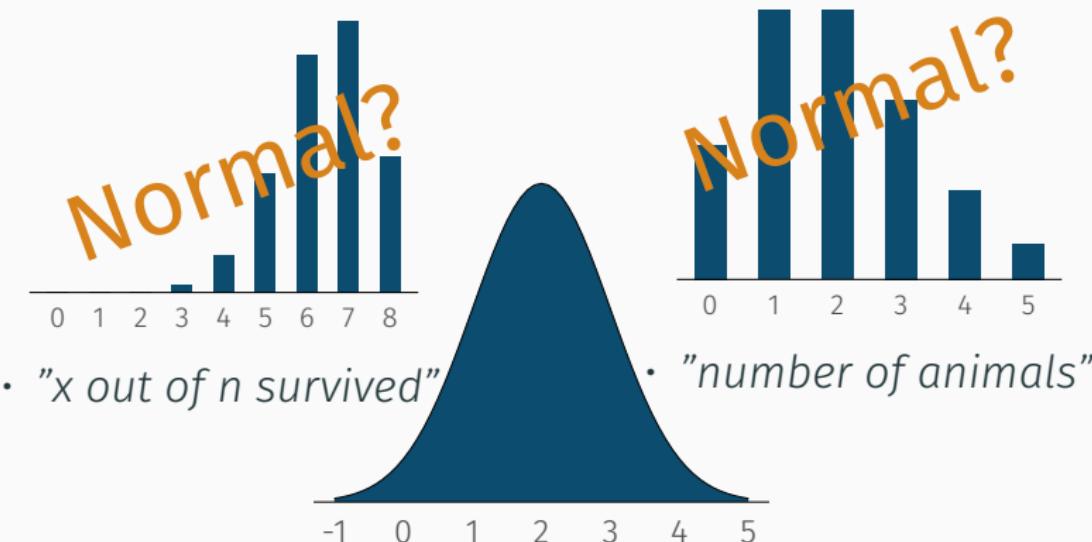


- " x out of n survived"



- "*number of animals*"

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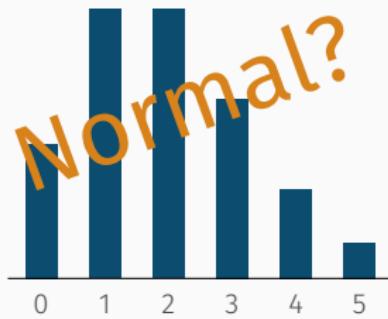


Ecotoxicology is not normal

Normal?



- " x out of n survived"



- "number of animals"

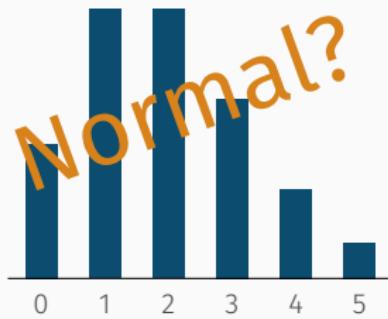
- ignore?

Ecotoxicology is not normal

Normal?

0 1 2 3 4 5 6 7 8

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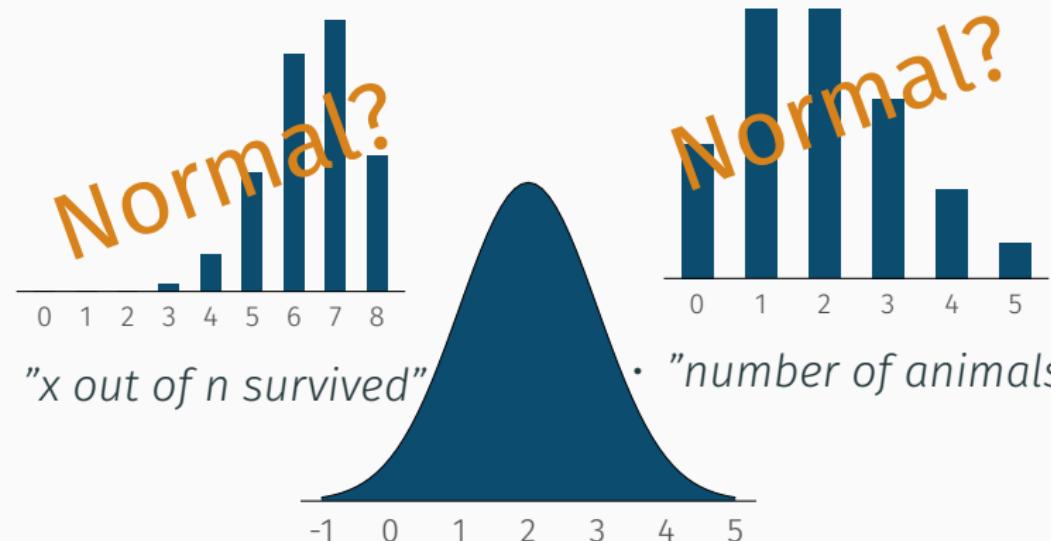


- "number of animals"

-1 0 1 2 3 4 5

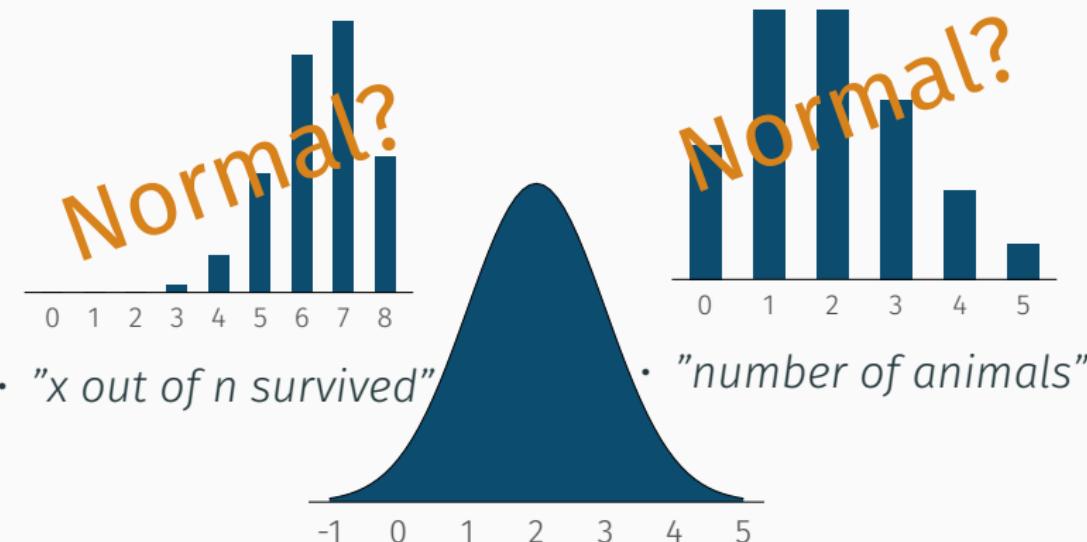
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 - non-parametric?
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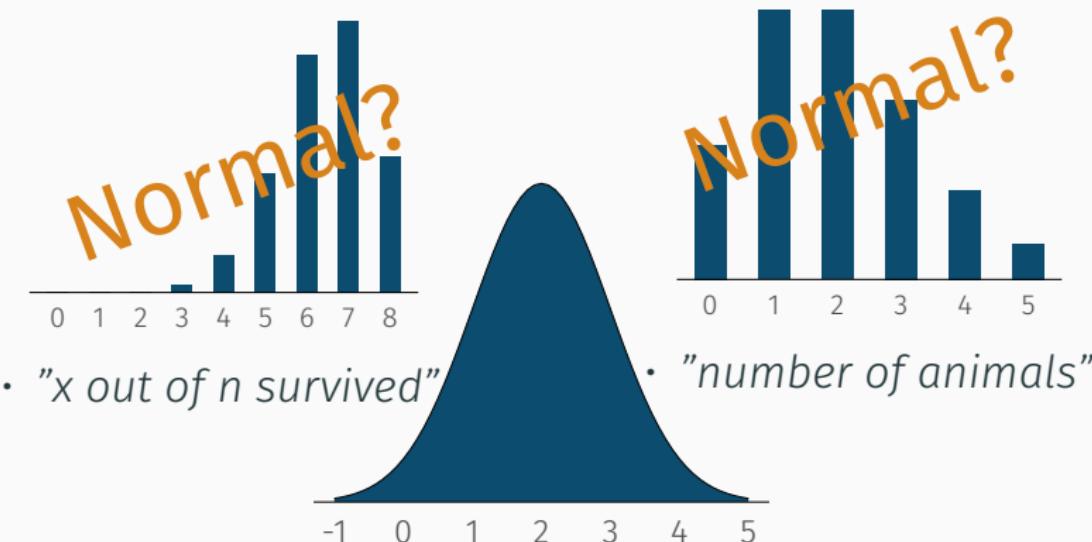
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- Generalised Linear Model (GLM)?

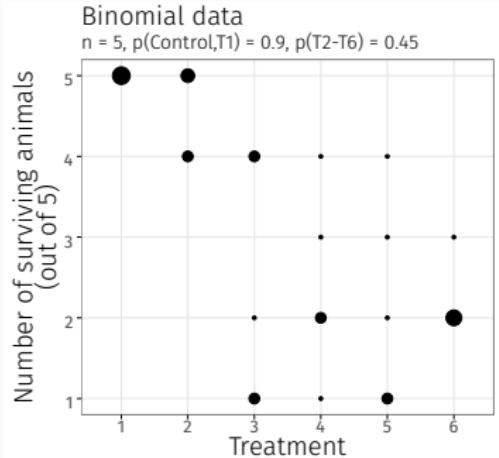
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- "x out of n survived"
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- Generalised Linear Model (GLM)?

Discussion on GLM + GLM short intro

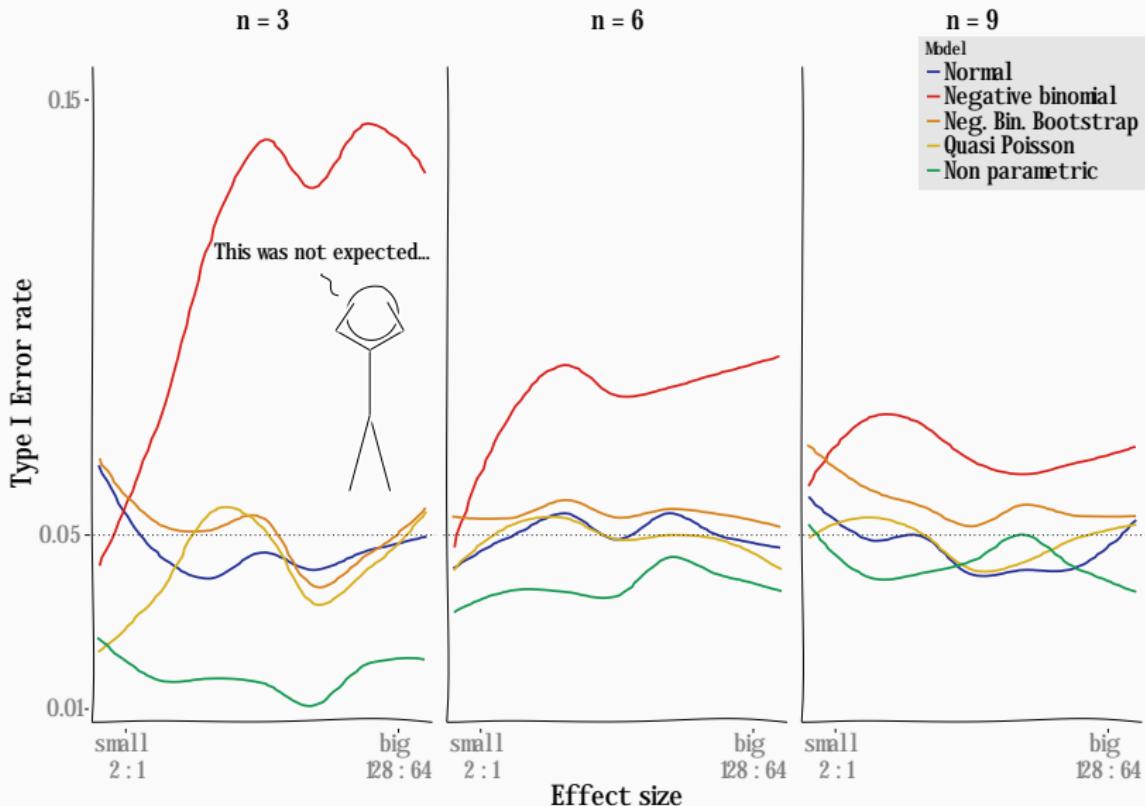
A simulation study



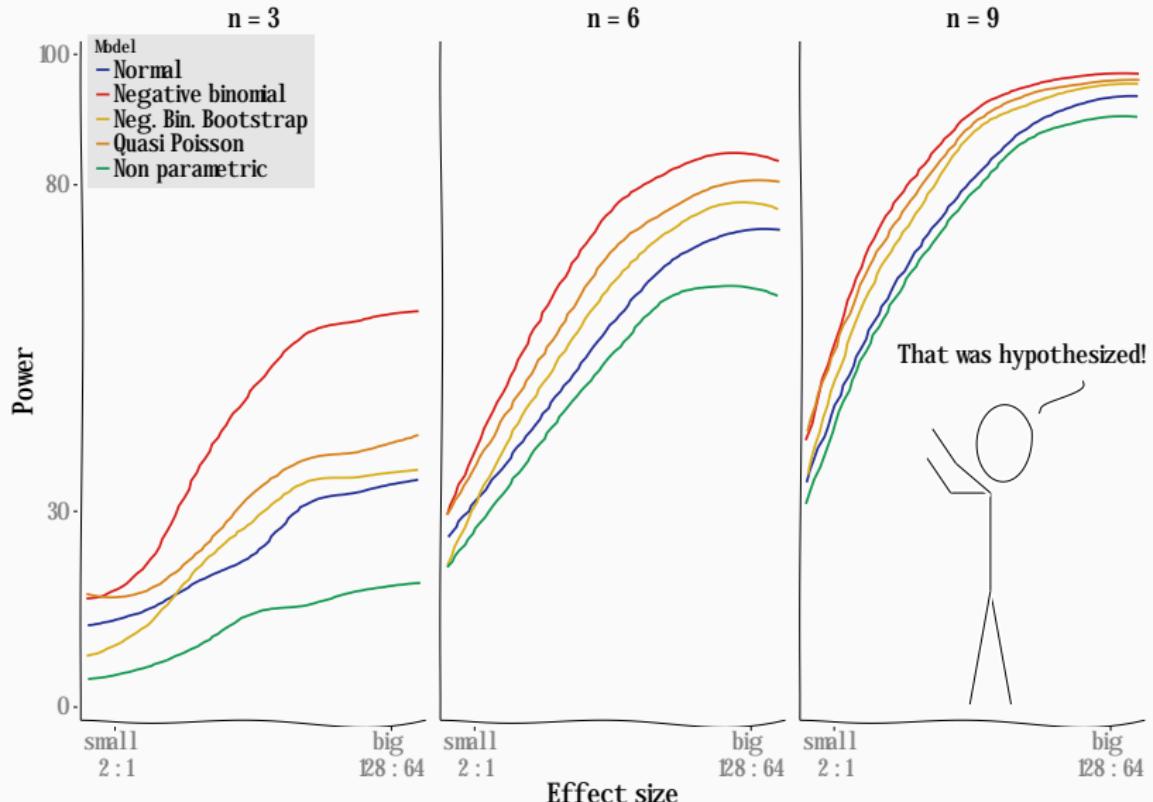
Simulation:

- Count & Binomial data
- Vary replicates & effect sizes
- LM, GLMs,
Non-parametric

Type I Errors: GLMs can fail



Power: But GLMs can do also better



What we learned from this study

1. Negative-binomial GLM show increased Type I errors
2. Can be fixed via bootstrap
3. GLMs can increase this power
4. Ecotoxicological experiments commonly low power

Methods in Ecology and Evolution



Methods in Ecology and Evolution 2016, 7, 882–890

doi: 10.1111/2041-210X.12552

FORUM

Three points to consider when choosing a LM or GLM test for count data

David I. Warton^{1*}, Mitchell Lyons², Jakub Stoklosa¹ and Anthony R. Ives³

¹School of Mathematics and Statistics and Evolution & Ecology Research Centre, University of New South Wales, NSW 2052, Australia; ²School of Biological, Earth and Environmental Sciences, University of New South Wales, NSW 2052, Australia; and

³Department of Zoology, University of Wisconsin-Madison, Madison, WI 53706, USA

Where are we today?

Methods in Ecology and Evolution



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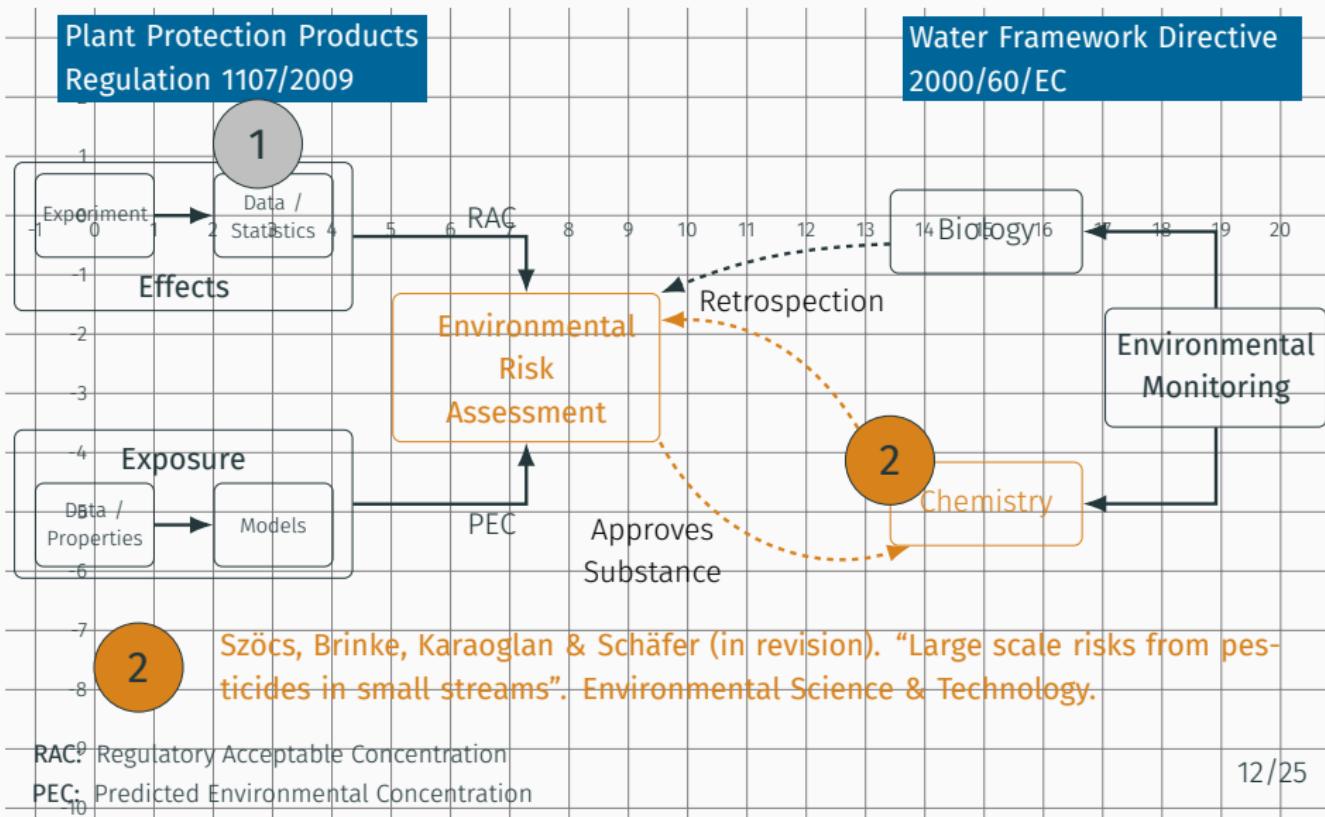
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State of the art

1. Choose your model based on data properties
2. Fix Type I errors by resampling
3. GLMs have greater power

Exploring Monitoring Data for ERA



Exploring Monitoring Data for ERA

Goals & Hypotheses

Goal: Combine monitoring and ERA

- Compile nation-wide monitoring data
- Focus on small streams
- Identify risks & influencing factors

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Hypotheses

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Hypotheses

1. Agriculture: \uparrow Risk: \uparrow
2. Stream size: \downarrow Risk: \uparrow

Goals & Hypotheses

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Hypotheses

1. Agriculture: \uparrow Risk: \uparrow
2. Stream size: \downarrow Risk: \uparrow
3. Precipitation: \uparrow Risk: \uparrow

Goals & Hypotheses

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- Focus on small streams
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Hypotheses

1. Agriculture: \uparrow Risk: \uparrow
2. Stream size: \downarrow Risk: \uparrow
3. Precipitation: \uparrow Risk: \uparrow
4. Annual dynamics - Summer: \uparrow

Analysing chemical concentrations

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$$y \sim ZAGA = \begin{cases} \text{Binomial GLM} & \text{if } y < LOQ \\ \text{Gamma GLM} & \text{if } y \geq LOQ \end{cases}$$

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- Risk Quotient

- $RQ = \frac{C}{RAC}$

Analysing chemical concentrations

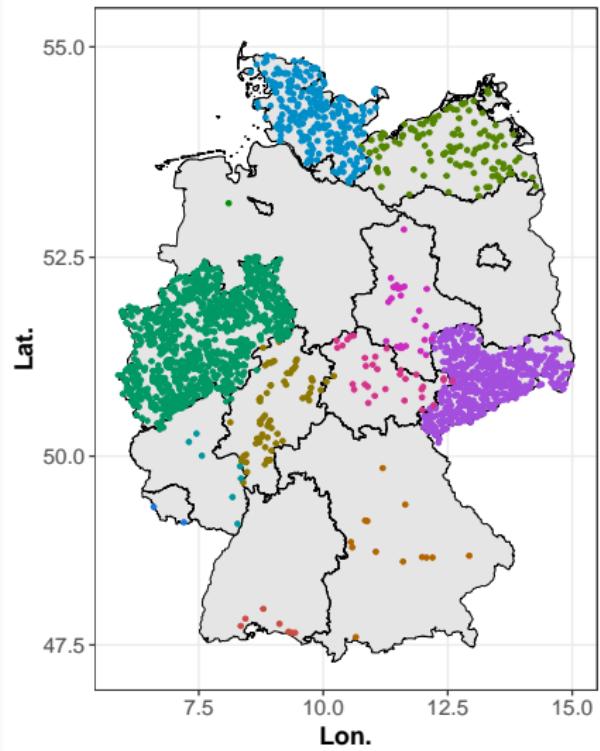
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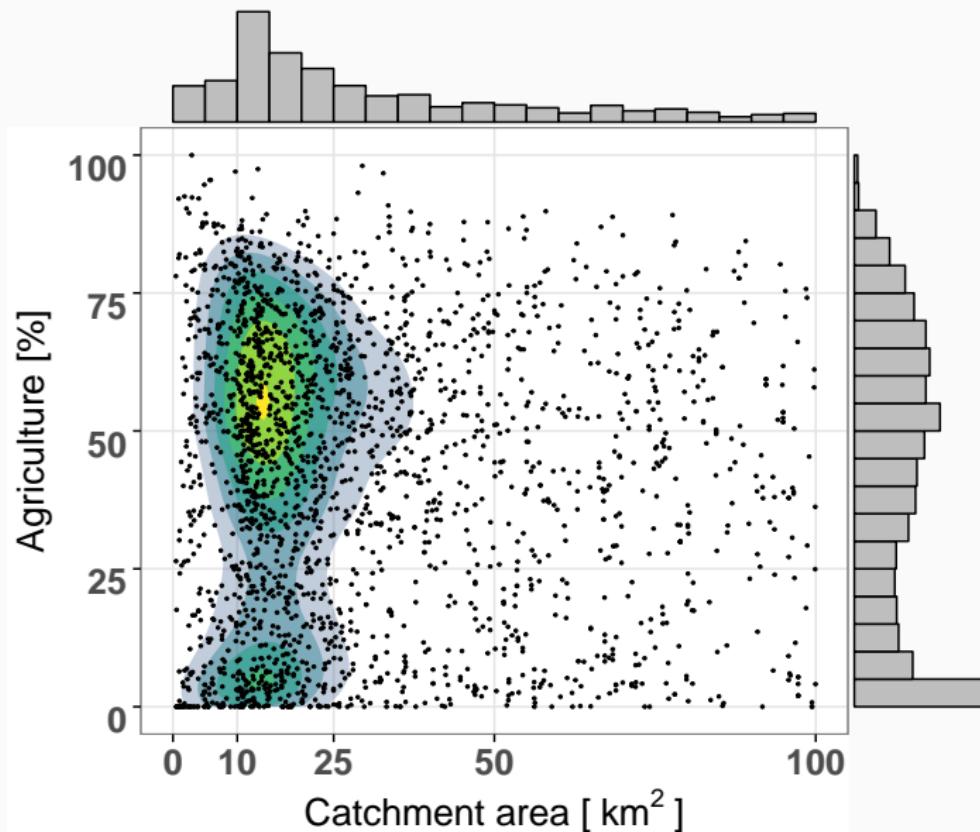
- Risk Quotient
 - $RQ = \frac{C}{RAC}$
- Predictors
 - Catchment size
 - Agricultural land use
 - Precipitation

Compiled data: Big, but inhomogeneous

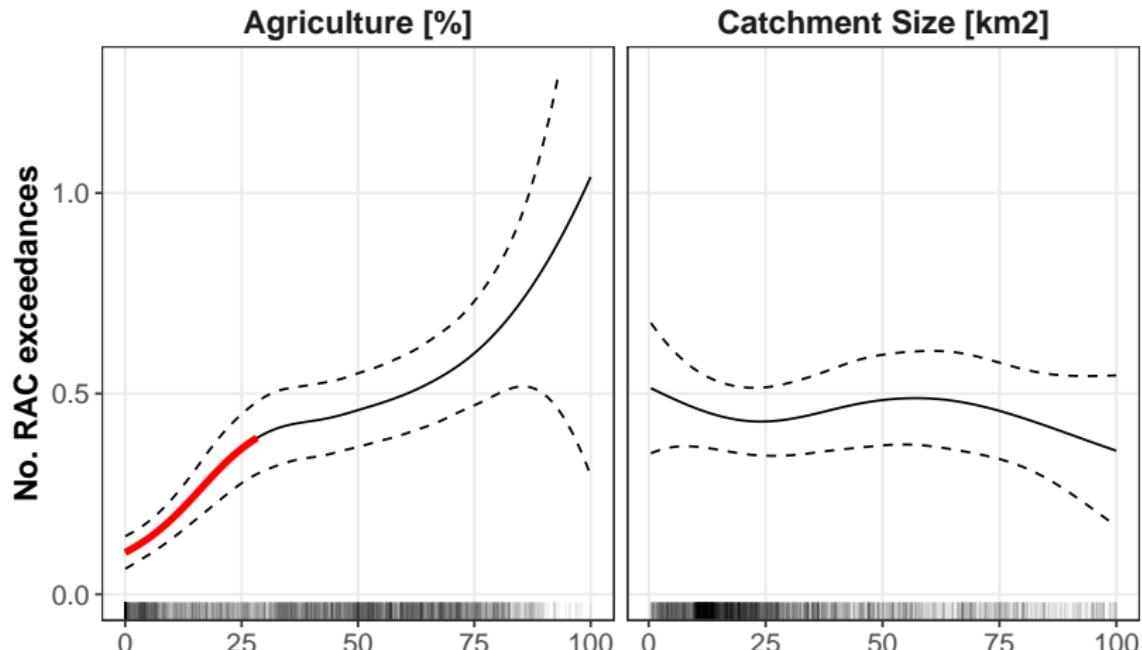
- ~ 1.8M measurements
- ~ 500 pesticides
- ~ 25,000 samples
- ~ 2,300 sites



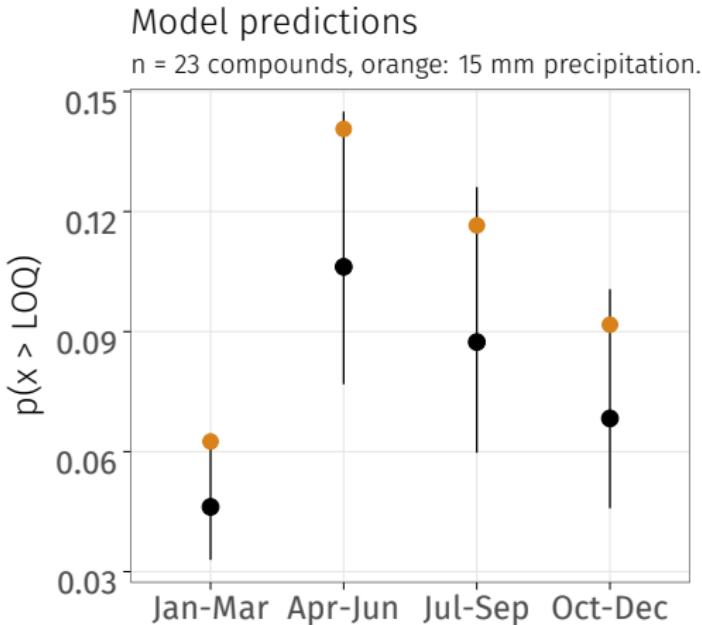
Monitoring: Small streams are underrepresented



Landscape: Factors influencing risk



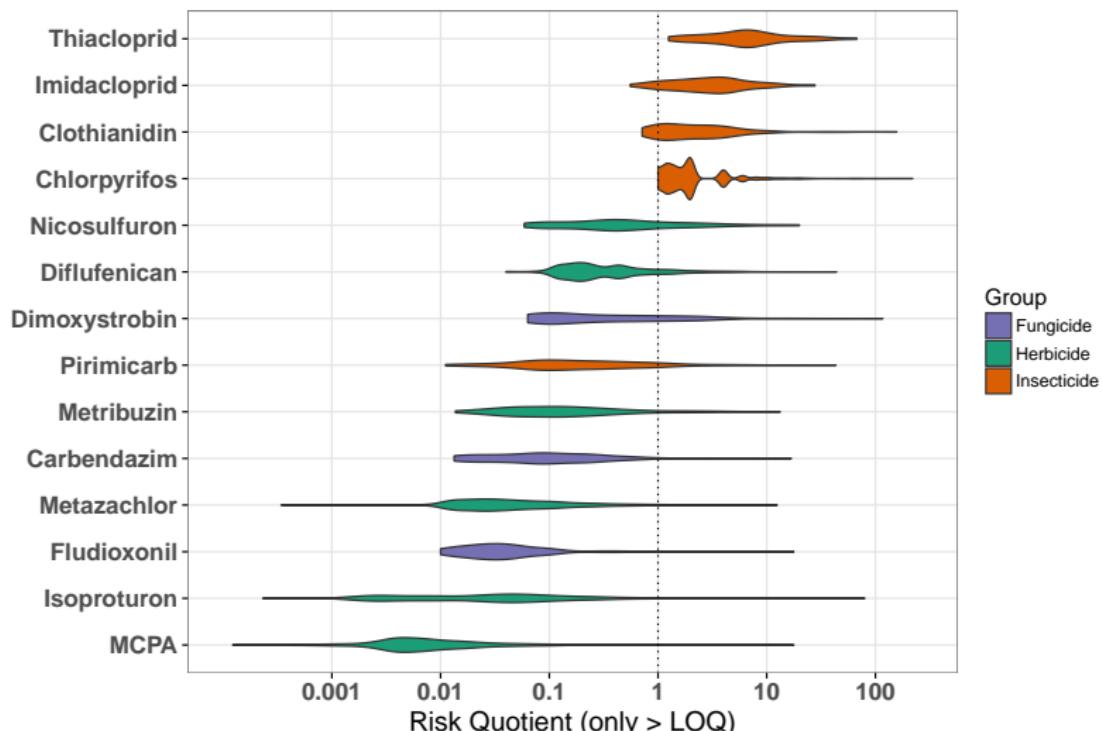
Sampling: Factors influencing risk



- Peak in summer
- Increase by precipitation
- absolute concentrations
>>variability

Risks: Compounds exceeding risk thresholds

- 25% of sites with at least one RQ > 1

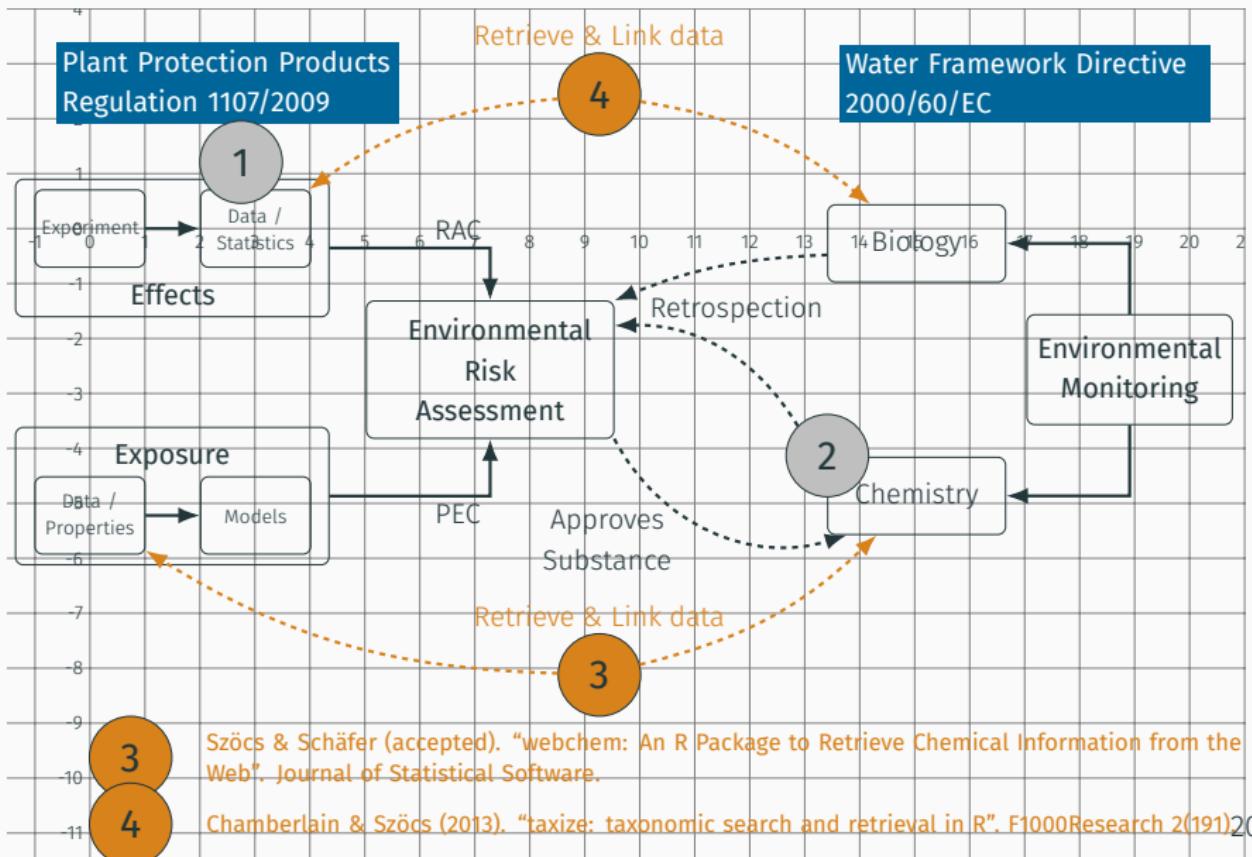


What we learned from this study

1. Differences between **states**
2. Small streams are **underrepresented**
3. **Agricultural** sources
4. **LOQ** gives additional insights
 - Annual **dynamics**
 - **Precipitation** increases concentrations
5. **Neonicotinoids**

Solutions for Data Handling in ERA

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Biologists & Chemists face the same problems

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Names

Osmia rufa, *Osmia bicornis*,
Osmia ruffa, *Osmiaxxxx*

Chlorpyrifos, Chlorpyriphos,
Chlorphyrifos, Chlorpypifot

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Hierarchies

Hymenoptera / Apoidea /	organophosphate, ester,
Megachilidae / Osmia / rufa	insecticide

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Traits / Properties

Wing length, Mass, Season	Mass, K_{OW} , LC_{50}
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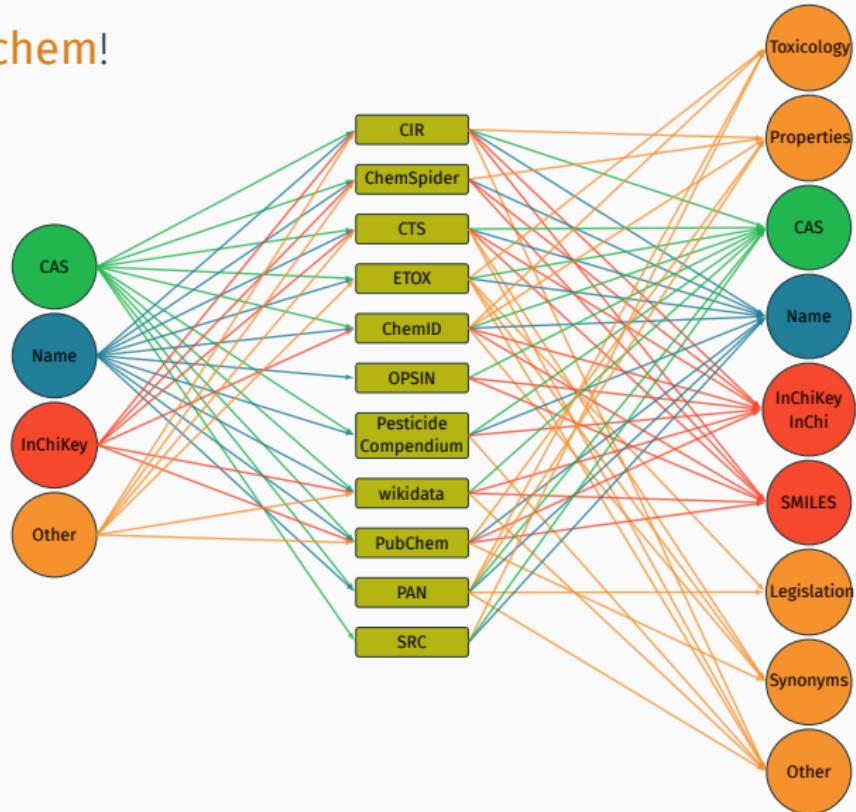
Amount of data

2993 taxa

478 pesticides

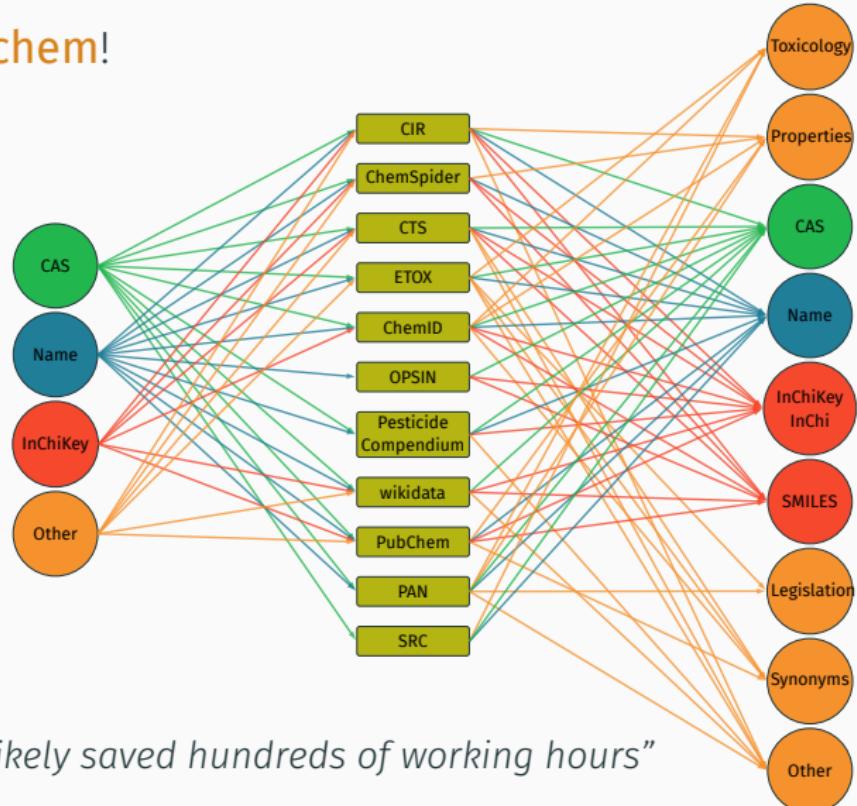
Instead of wasting time...

... use webchem!



Instead of wasting time...

... use webchem!



"webchem ...likely saved hundreds of working hours"

Instead of wasting time...

... use **taxize!**



Global Invasive Species
Database



Catalogue of Life



Plantminer



Encyclopedia of Life



Canadensys

ThePlantList

Instead of wasting time...

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Global Invasive Species
Database



ITIS

iPlant
Collaborative™



Plantminer

Catalogue of Life

Tropicos®

eol

gni

RED LIST



Susan Johnston
@SuseJohnston



Folgen

Discovered taxize taxonomic toolbelt for R on
@rOpenSci. Days of searching done during my
morning coffee. Amazing. ropensci.org/tutorials/taxi...

Übersetzung anzeigen

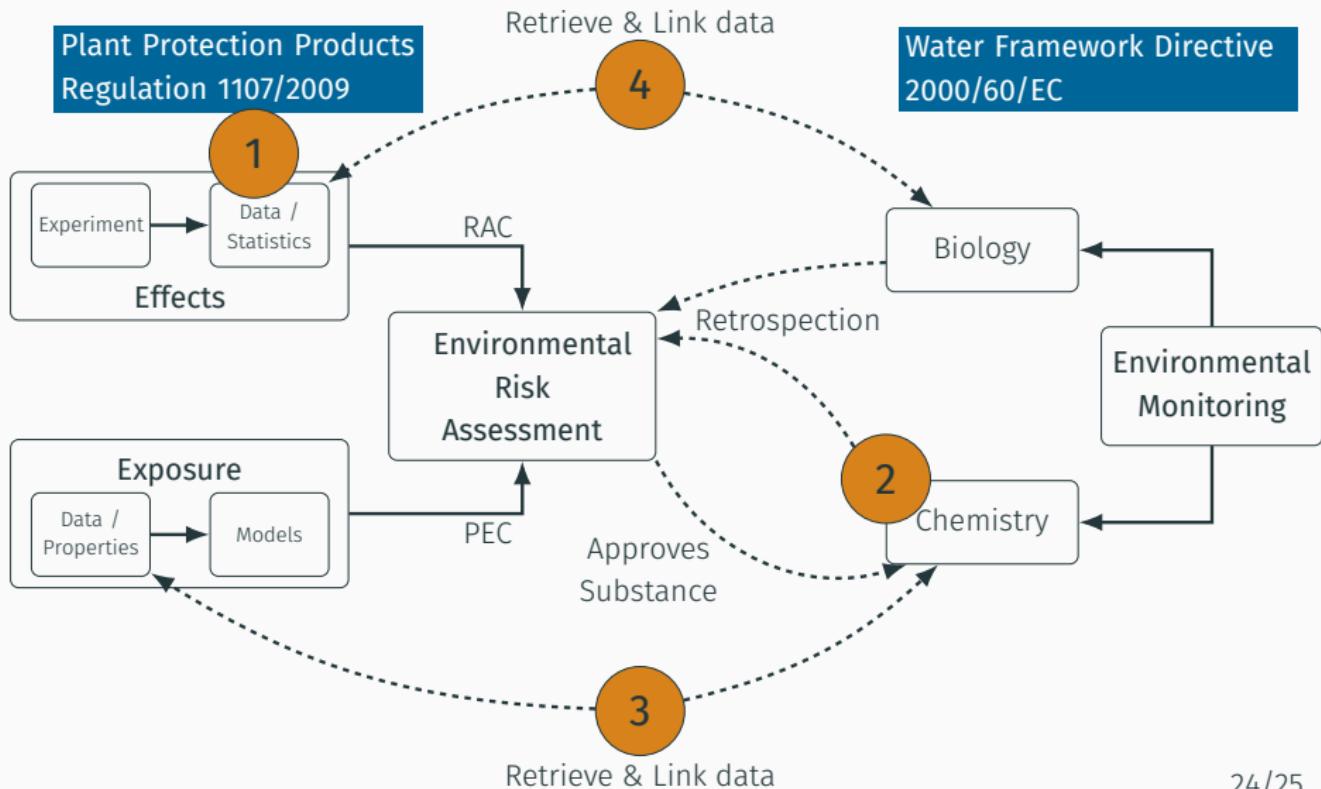
RETWEETS
8

GEFÄLLT
17



Recap

Recap: What did I look at?



Recap: What we learned from my PhD Thesis

✓ Improving Statistics in ERA

- Change your model, not your data
- Take LOQ into account

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- Risk drivers and dynamics
- Agricultural small streams neglected & at risk
- Neonicotinoids

Recap: What we learned from my PhD Thesis

✓ Improving Statistics in ERA

- Change your model, not your data
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✓ Exploring Monitoring Data for ERA

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✓ Solutions for Linking Data in ERA

- Handling big eco(toxico-)logical data not easy
- Now easier

Statistical Ecotoxicology

Improving the Utilisation of Data for
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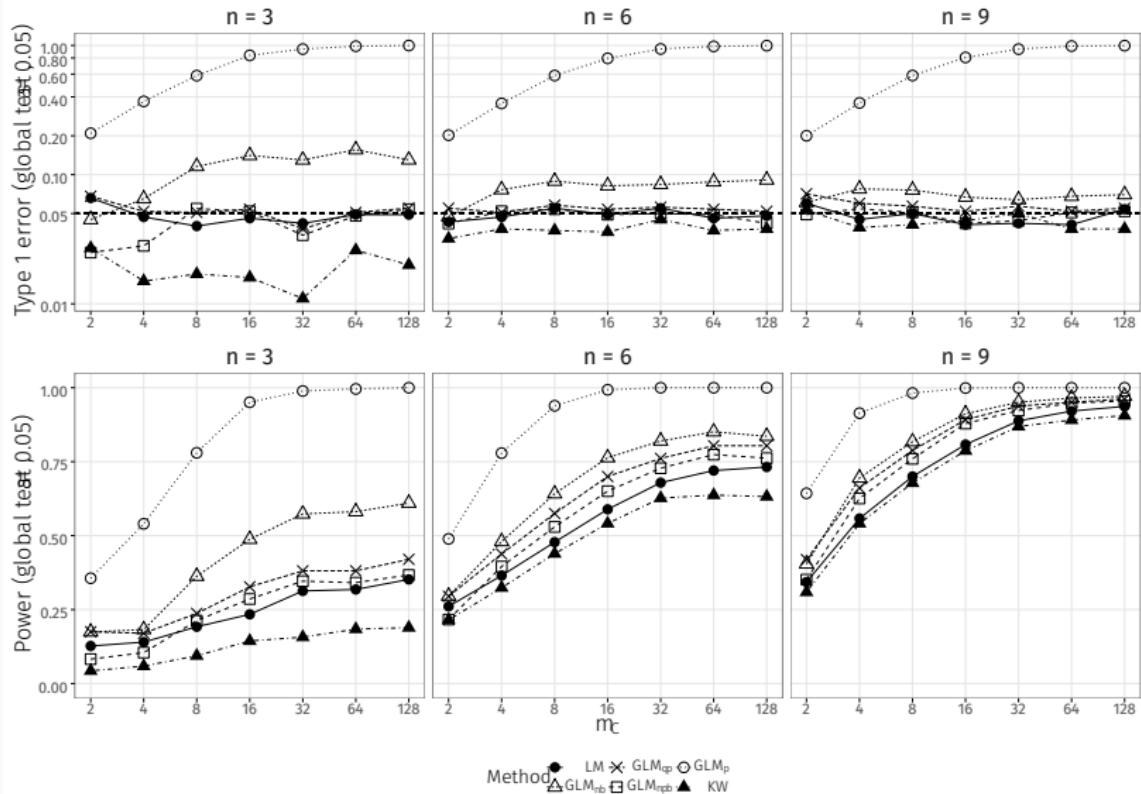
□ <http://edild.github.io/>

🐦 [@EduardSzoebs](https://twitter.com/EduardSzoebs)

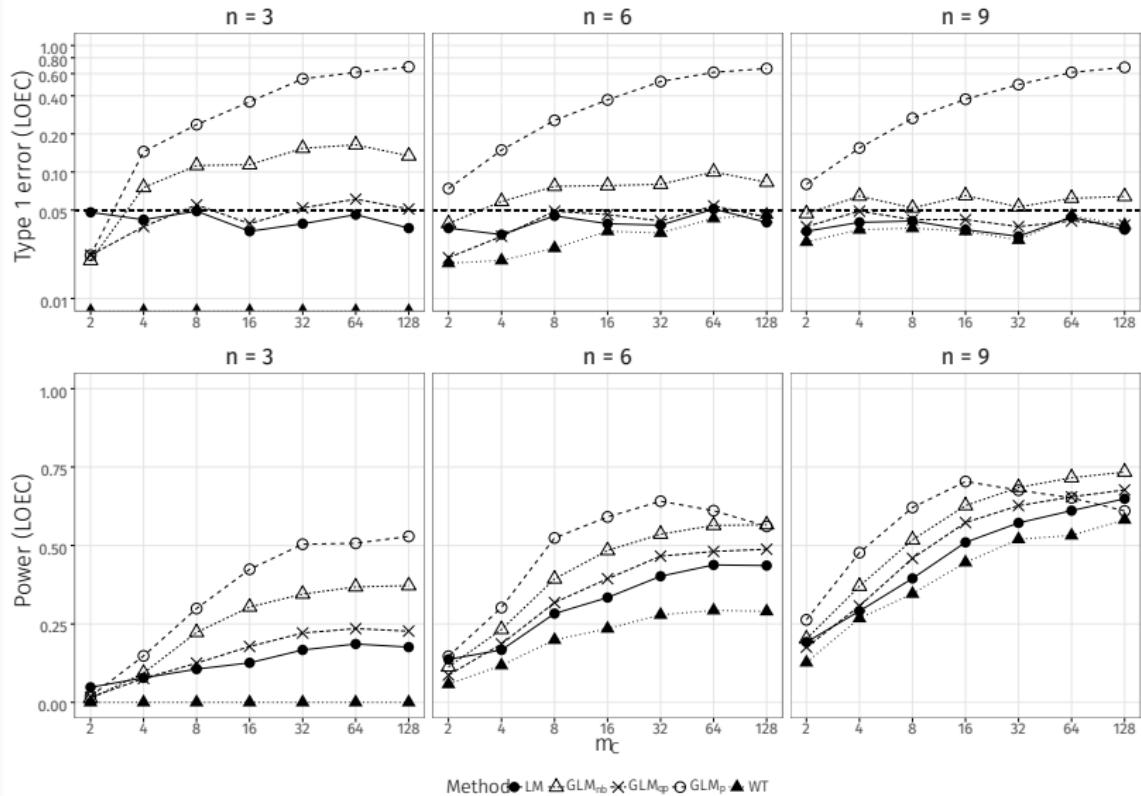
📄 https://github.com/edild/phd_defense

📄 https://github.com/edild/phd_thesis

Power en detail



For LOEC it is even worse

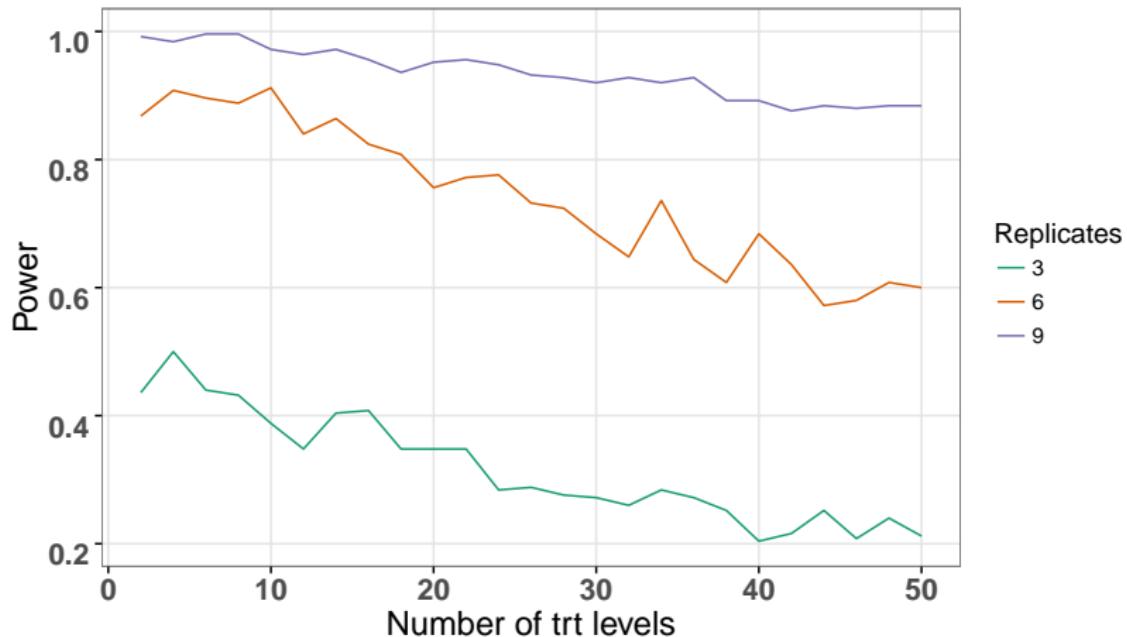


Effect of number of treatments

Power analysis for different numbers of treatment levels.

Treatment mean = 100, last treatment was reduced to 80.

Distribution: Norman; Link: Identity; Sigma_res = 10;
250 simulation runs per scenario



Comparison with Ives...

Szöcs (2015)

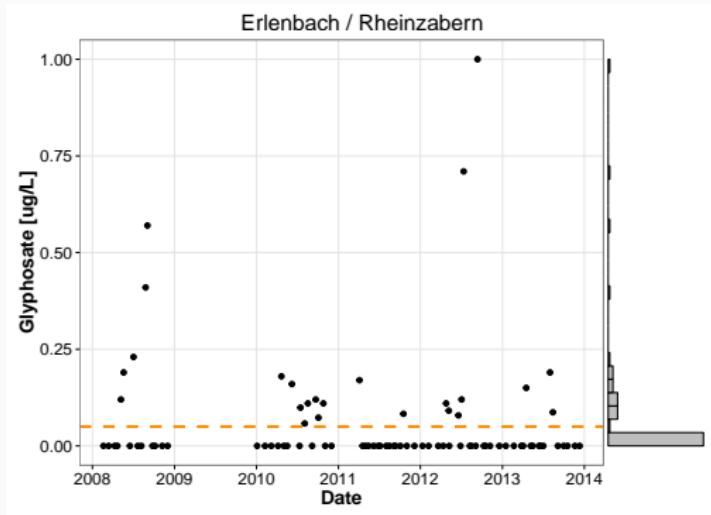
- factorial design
- one predictor
- low replicated
- LM, GLM, bootstrap
- High T1 error of NB
- Quasi-Poisson worked well
- Bootstrap fixes the problems

Ives (2015)

- continuous design
- two predictors
- well replicated
- LM, GLM
- High T1 error of NB
- Quasi-Poisson has problems with multiple predictors
-

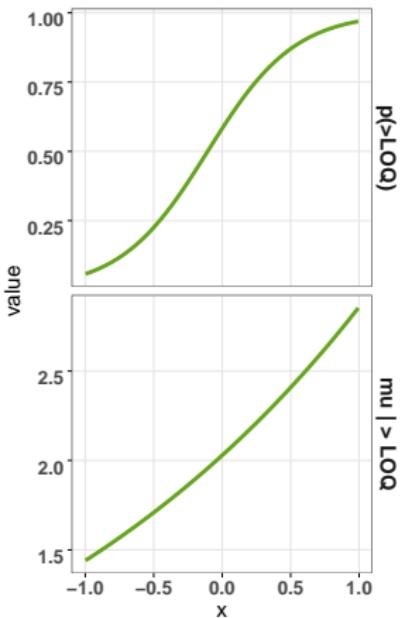
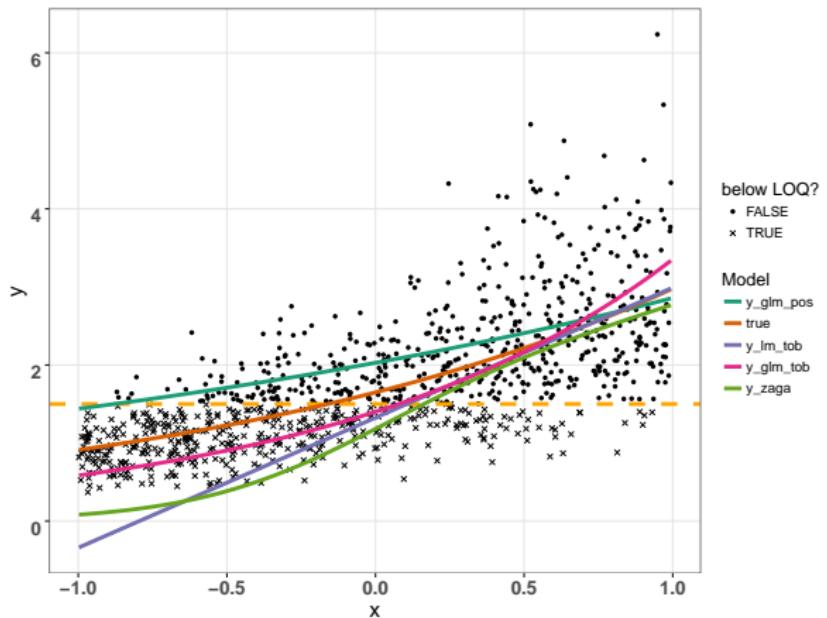
Idiosyncrasies of chemical concentrations

- continuous distribution in \mathbb{R}_0^+
 - censoring ($x < \text{LOQ}$)
 - non-linearity (season, trends)
 - dependency (spatial, temporal)
 - missing data

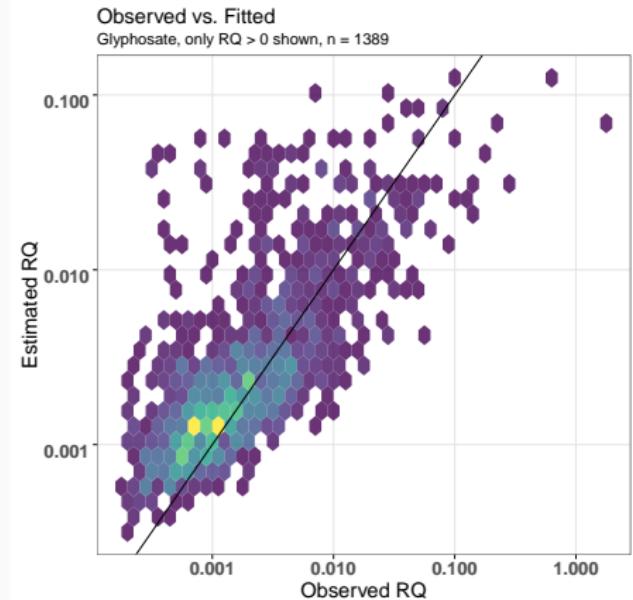
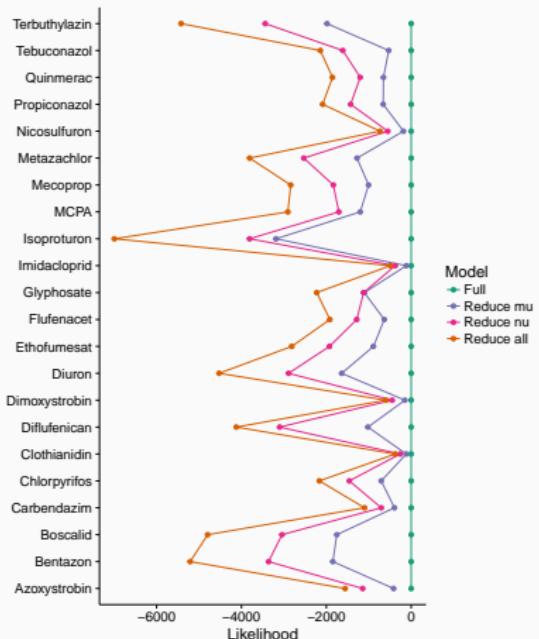


ZAGA what...?

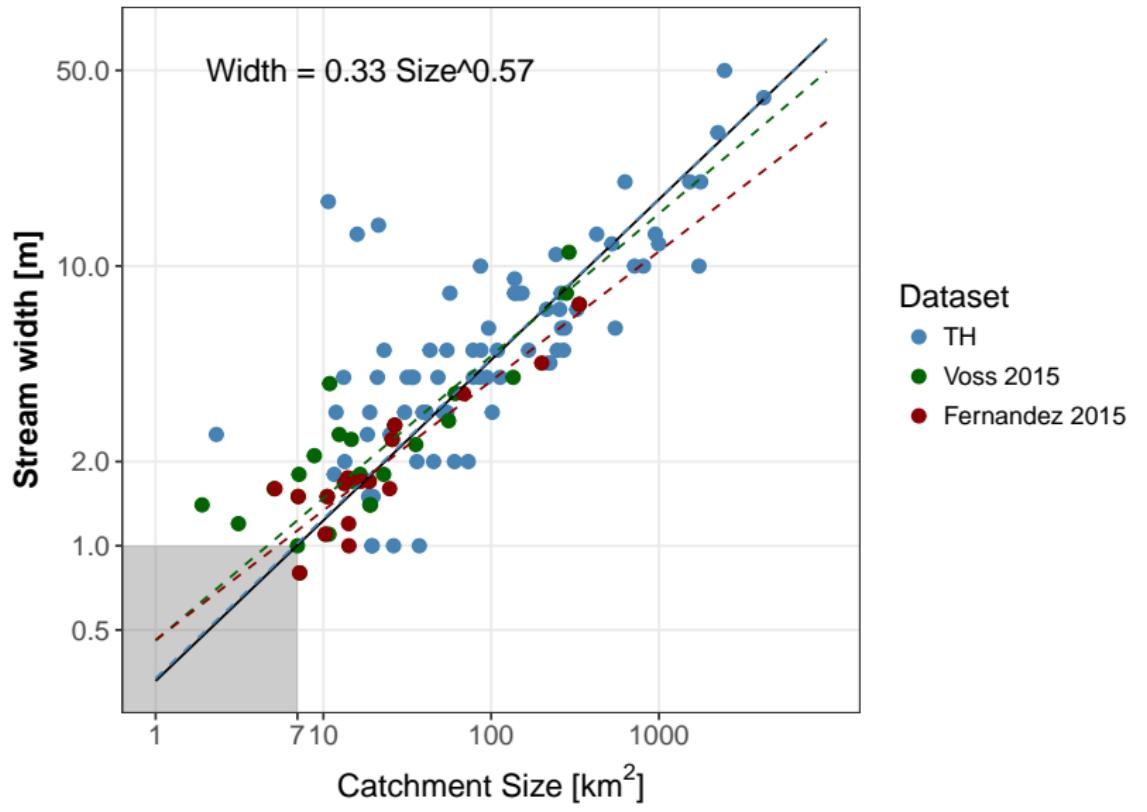
shiny app: <http://uni-ko-ld.de/g4>



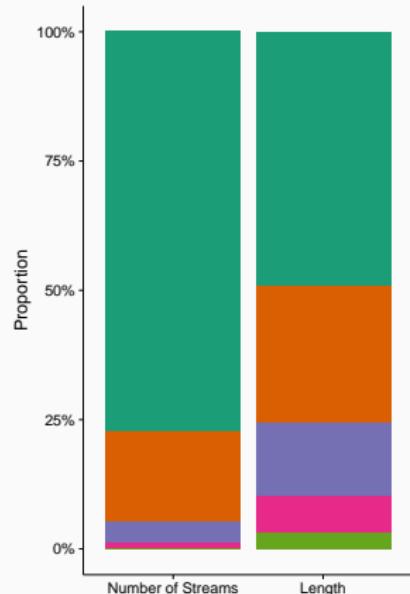
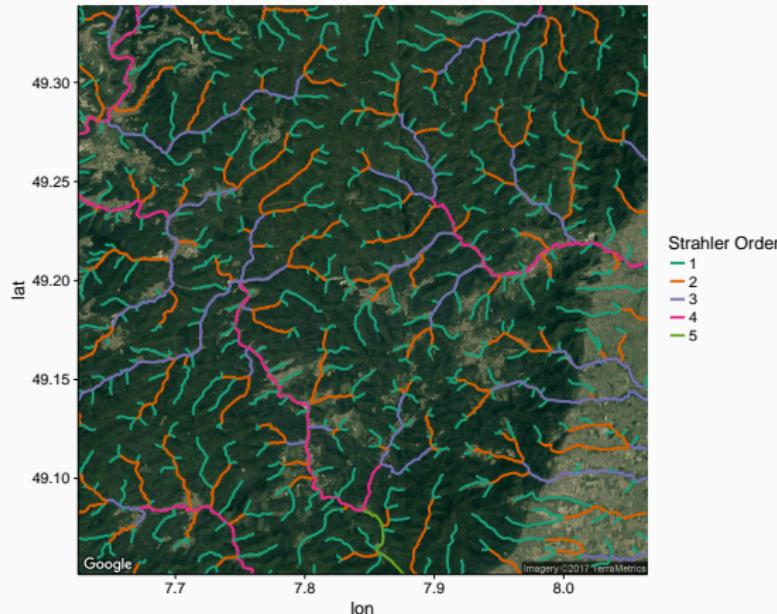
Model Performance



Stream size - width relationship



Small streams in the landscape

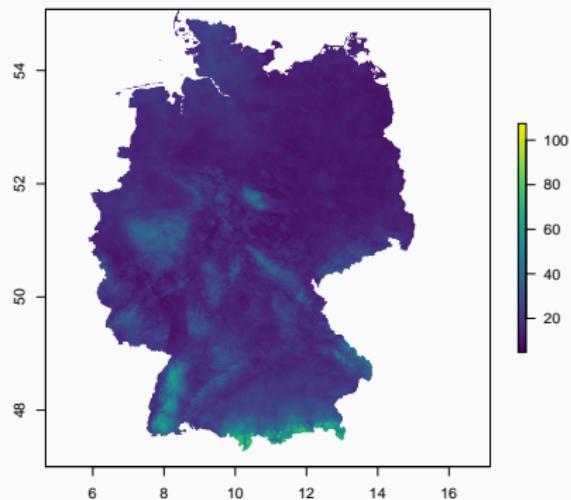


- Biodiversity
- Refuge for re-colonisation

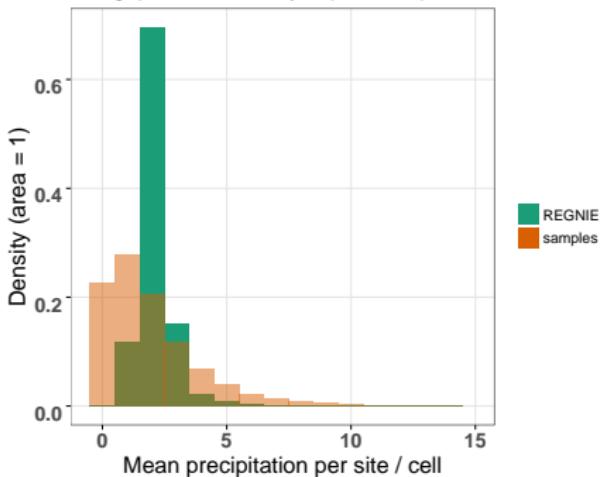
Biggs et al. (2016). The importance of small waterbodies for biodiversity and ecosystem services: implications for policy makers. *Hydrobiologia*. DOI: 10.1007/s10750-016-3007-0.

Precipitation in Germany and the samples

Mean # days > 10mm (REGNIE, 2005–2015)



Distribution of precipitation at sites / cell
Average per site / cell within year (2005–2015)



Comparison with other studies

Szöcs (2016)

- Germany
- Monitoring
- Grab sampling
- Pesticides
- Neonics + Chlorpyrifos (OP)
- ZAGA (<LOQ)

Stehle (2015)

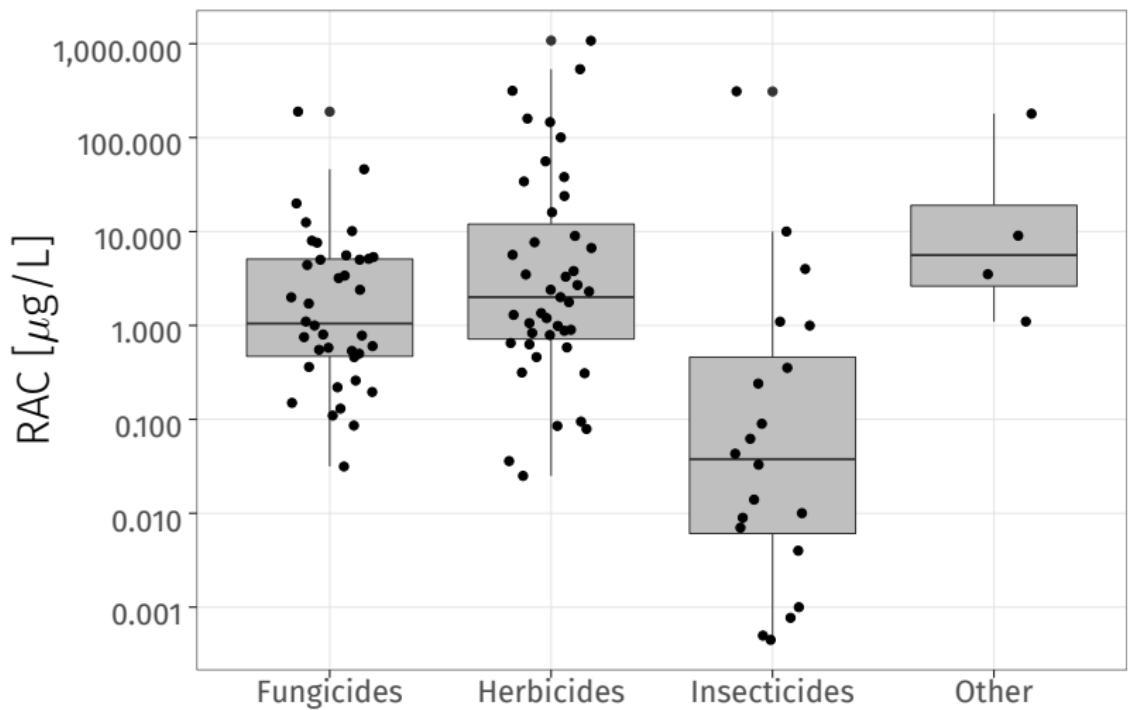
- Europe / Global
- Publications
- Grab & Event driven sampling
- Insecticides
- Organophos.+ Pyrethroids
- LM for >LOQ

Knauer (2016)

- Switzerland
- Monitoring
- Grab sampling
- Pesticides
- Chlorpyrifos + Herb + Fung
- no model

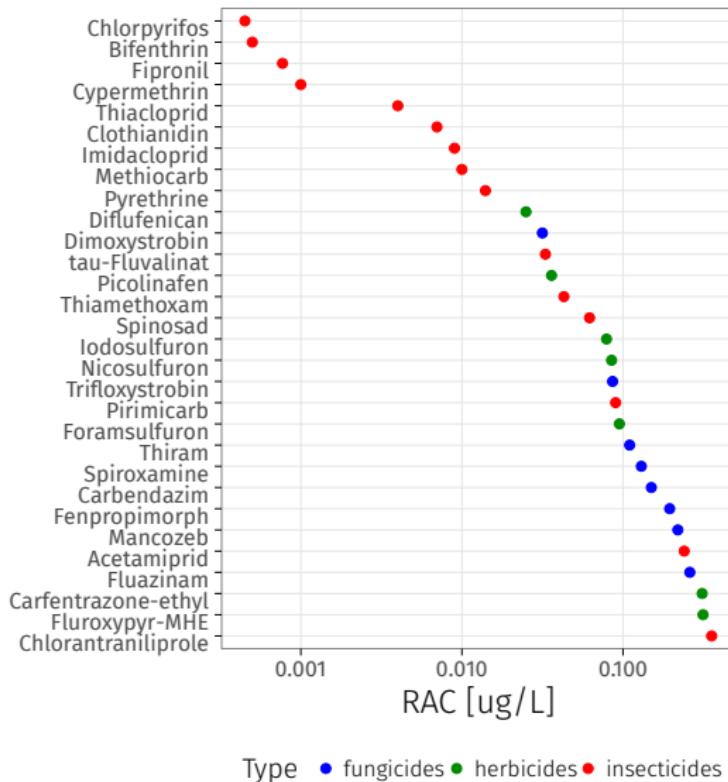
RACs by Type

105 RACs provided by UBA splitted by group

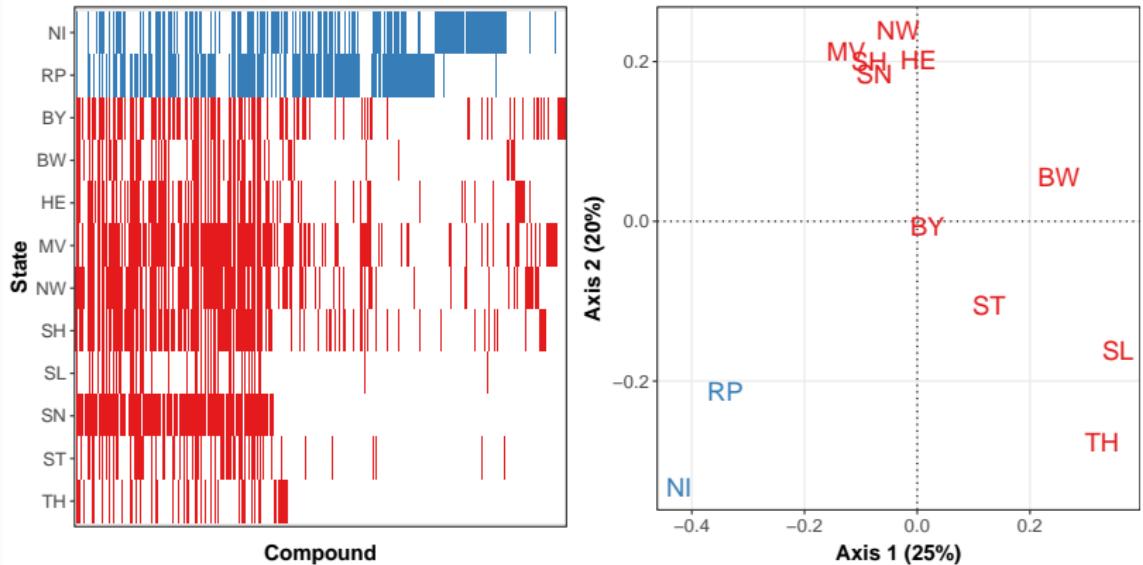


RACs by Compound

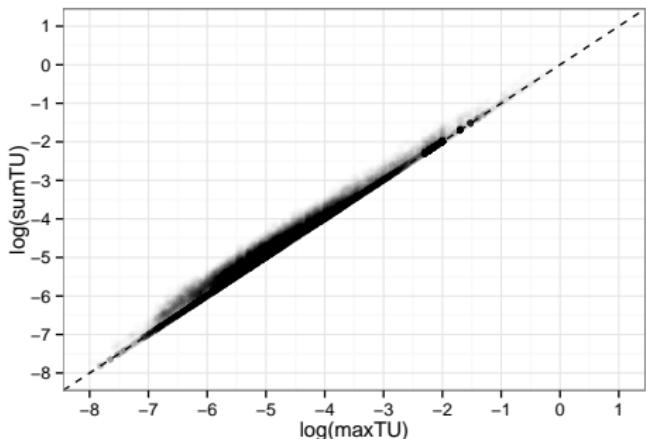
30 lowest RACs



Analysed compound spectra by state



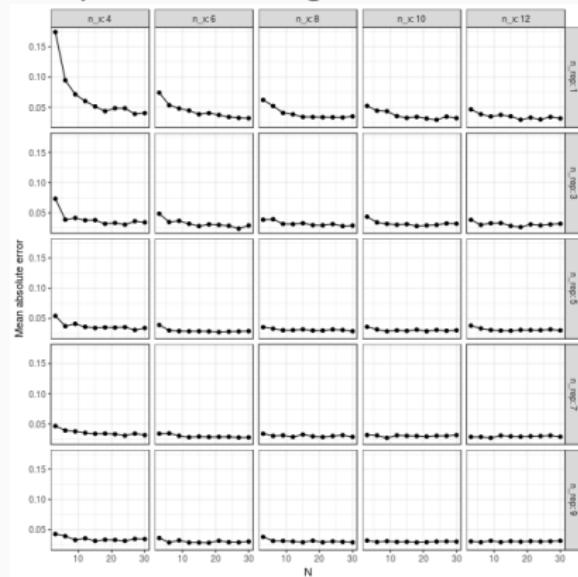
Mixtures are common, but one compound dominates the risk



- up to 50 compounds in one sample
- high correlation
- ~ 0.5 TU increase
- mainly one compound responsible for risk

Simulations are worth their work, use them *a priori*!

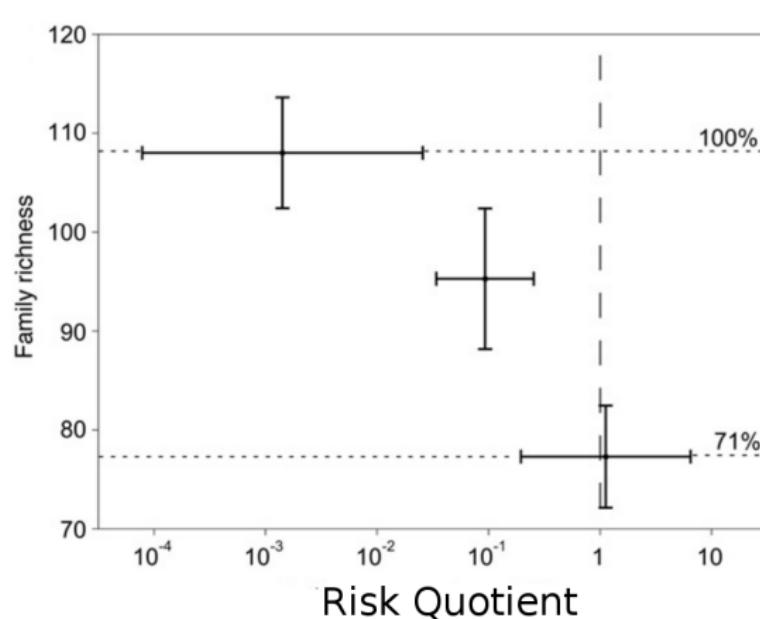
Experimental design for dose-response experiments - a simulation
http://edild.github.io/lc50_bias_sim/



GLM-Explorer: <http://uni-ko-ld.de/g3>

Effects of RAC exceedances

- RACs should never be exceeded (=protection goal)
- If so, biological effects likely



Modified from: Stehle, Schulz (2015). Agricultural insecticides threaten surface waters at the global scale. PNAS 112, 5750–5755.

Reasons for observed RAC exceedances

- Risk Mitigation fails
 - Risk mitigation measures (erosion rills, wind)
 - Farmer do not adhere (GAP, no spray zones)
- Risk Assessment fails
 - Exposure Assessment
 - Models not working (Knäbel et al.)
 - Effect Assessment
 - Missed sensitive species
 - New document asks also for insects

Risk Mitigation Measures

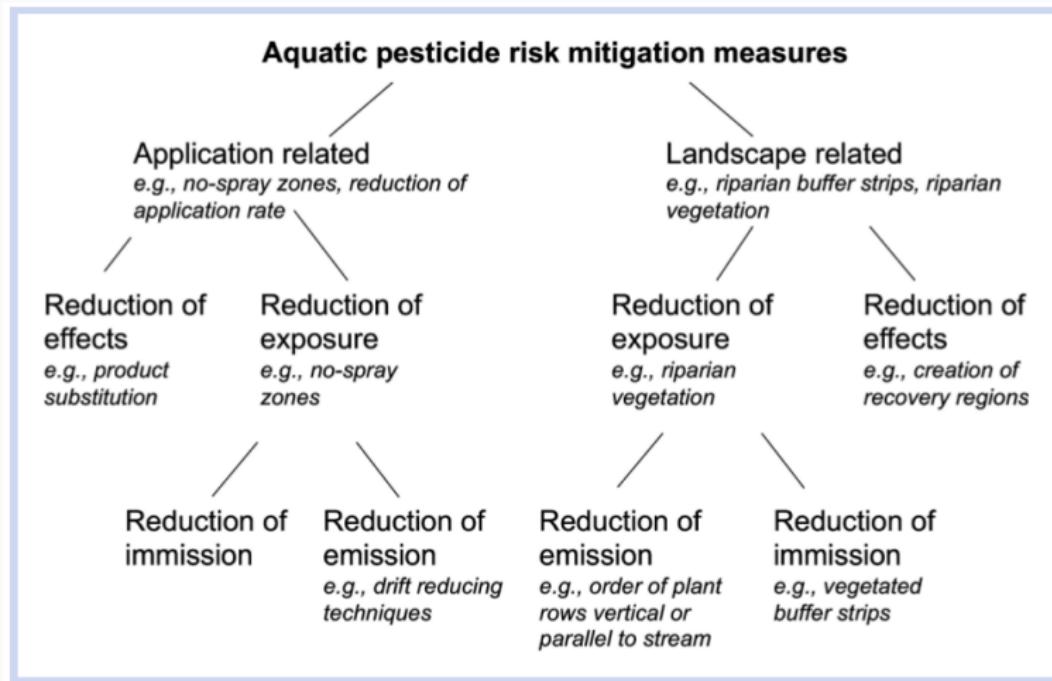
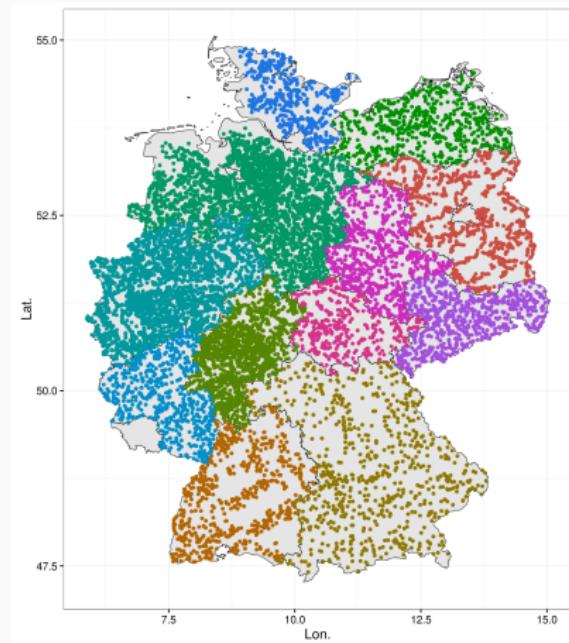


Figure 1. Classification of pesticide risk mitigation measures.

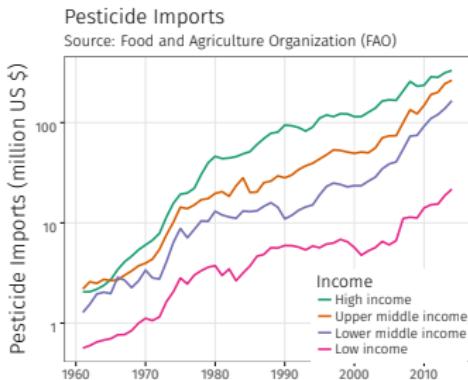
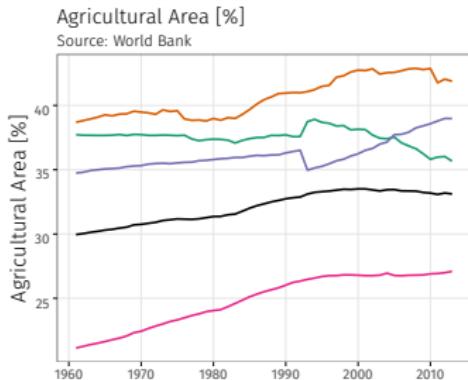
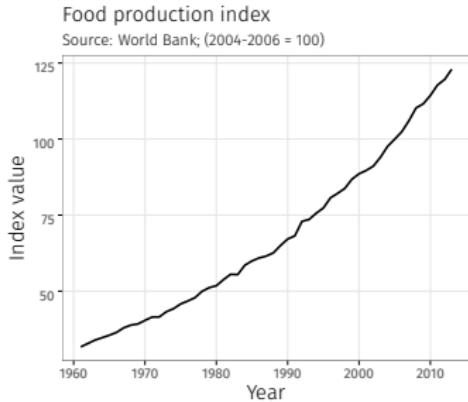
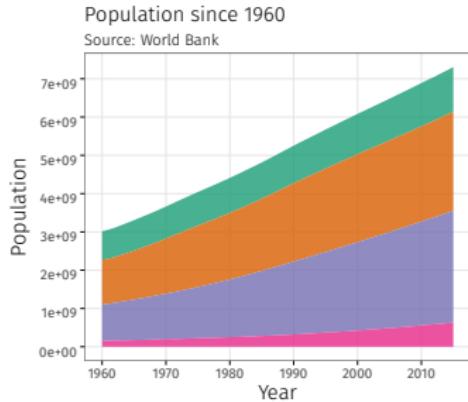
Bereswill, Strelcok, Schulz (2014). Risk mitigation measures for diffuse pesticide entry into aquatic ecosystems: Proposal of a guide to identify appropriate measures on a catchment scale: Guide to Identify Pesticide Risk Mitigation Measures. *IEAM* 10, 286–298.

Biotic field effects



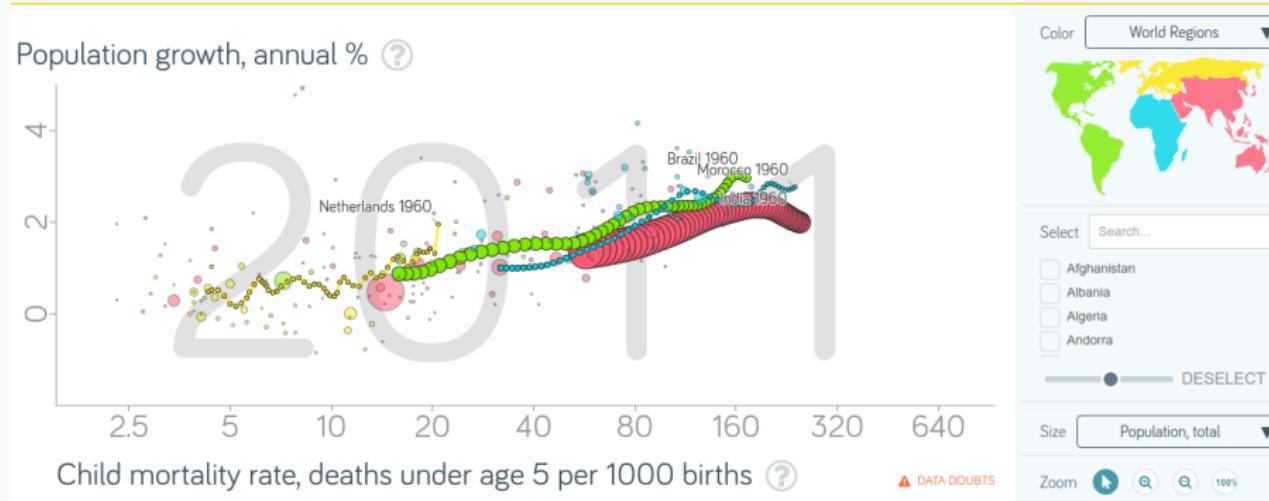
- biological data with good spatial coverage
- 60% of spatial congruence
- Large scale effects largely unknown.
- Some work left...
- Future....

A global perspective (I)



Source code to retrieve data and reproduce results:
<http://uni-ko-l.de/g7>

A global perspective (II)



Source: <https://www.gapminder.org/tools>

Software availability

Stable versions on CRAN, dev versions on github.

`webchem` github.com/ropensci/webchem

`taxize` github.com/ropensci/taxize

Best practices for Software:

- open source (permissive MIT License)
- version control (git)
- automated tests (Travis-CI)
- in source documentation (roxygen)

Many Thanks To

- My supervisor Prof. Dr. Ralf. B. Schäfer (for support, openness, opportunities & discussions)
- My colleagues & collaborators (to many to list here)
- German Environment Agency (for funding & collab)
- My parents Anca & Helmut (for their support)
- My girlfriend Anja (for everything)