Statistical Eco(-toxico)logy

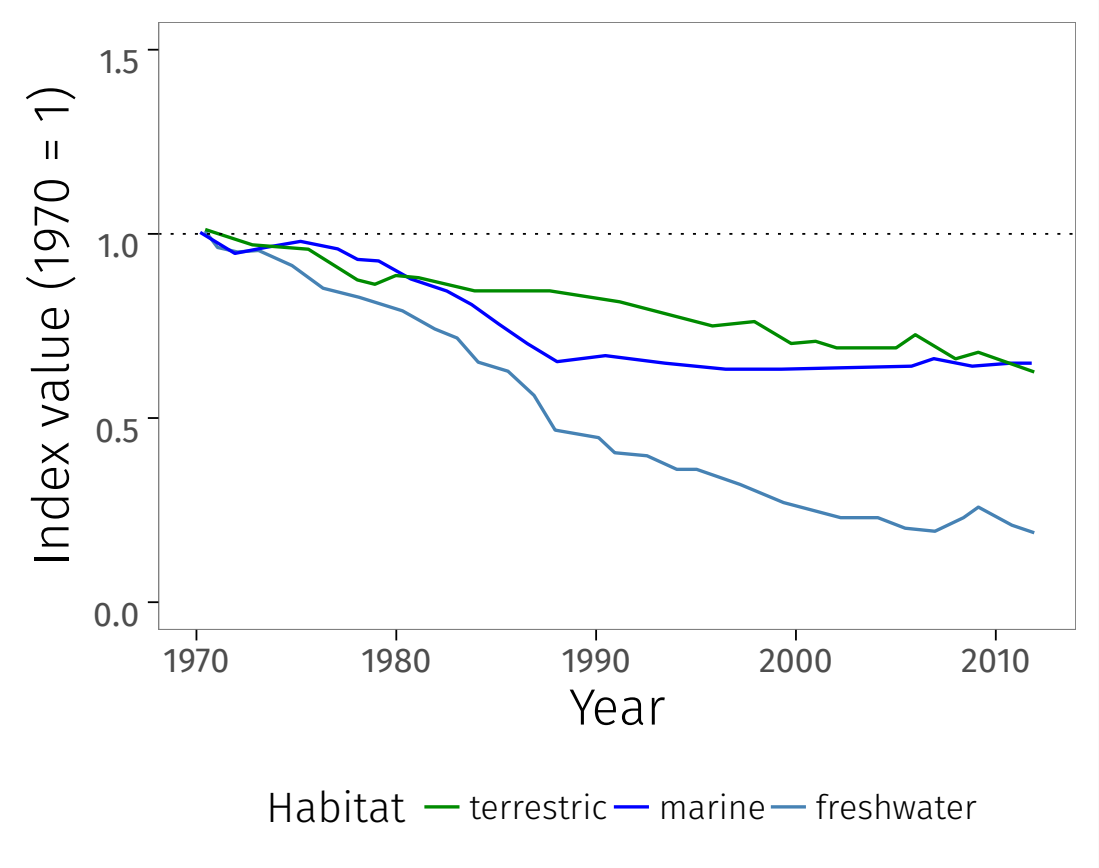
Improving the Utilisation of Data for Environmental Risk Assessment

Eduard Szöcs

25th January 2017

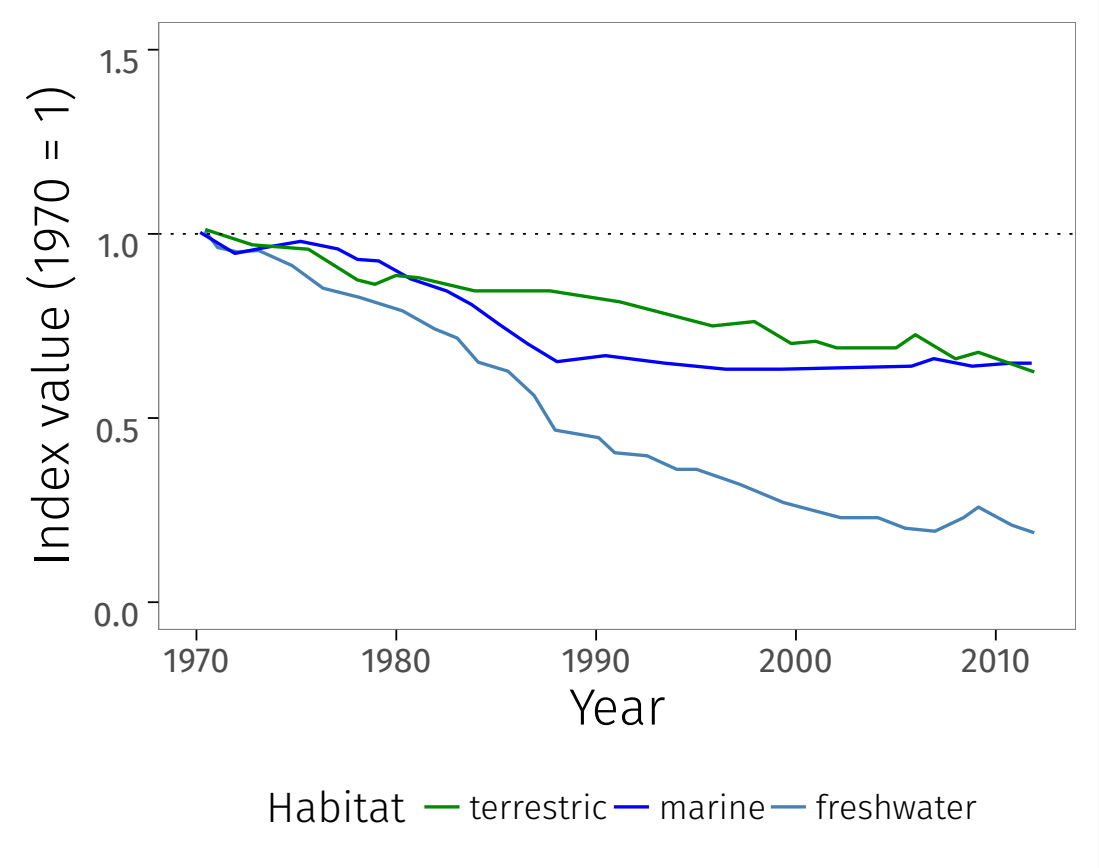
Table of contents

Freshwater biodiversity is strongly declining



WWF (2016), Living Planet Report; Vörösmarty (2010). Nature.

Freshwater biodiversity is strongly declining



Threats

- Habitat loss
- Overexploitation
- Pollution
- Invasive species

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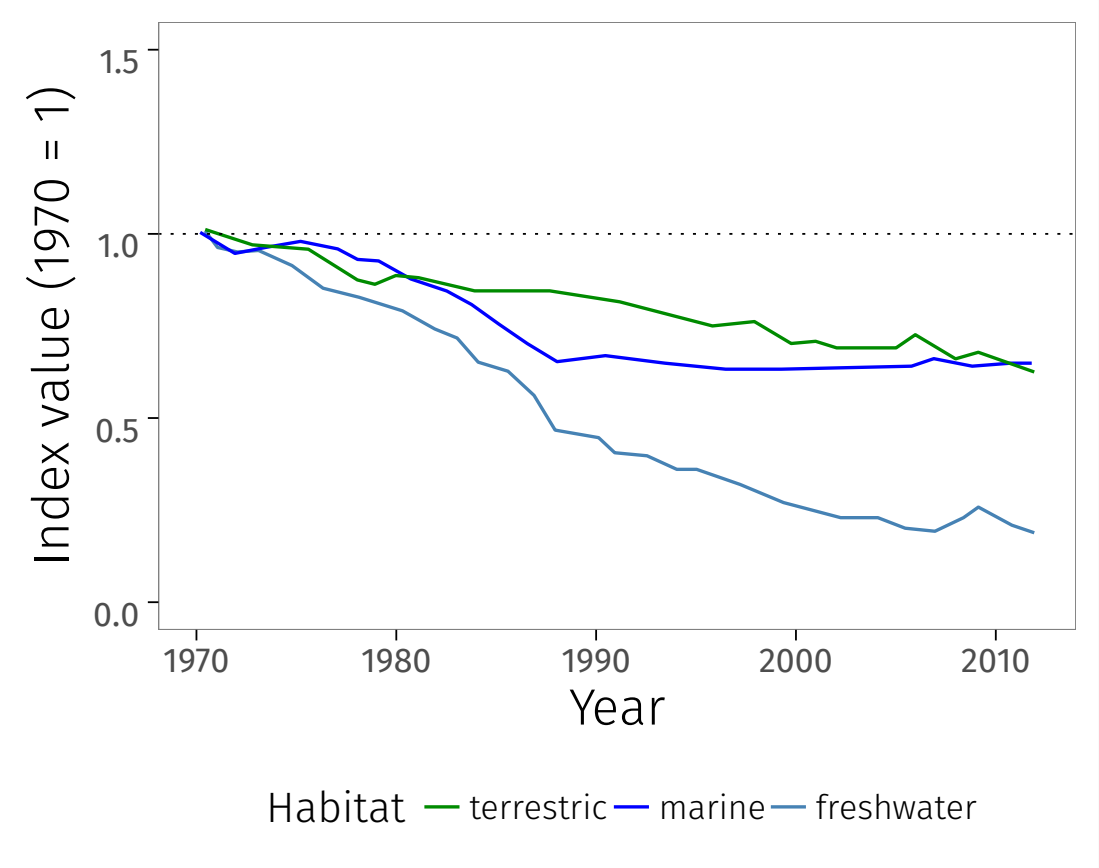
Freshwater biodiversity is strongly declining



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Environmental Risk Assessment and Environmental Monitoring

Environmental Risk Assessment and Monitoring

Plant Protection Products
1107/2009

Water Framework Directive
2000/60/EC

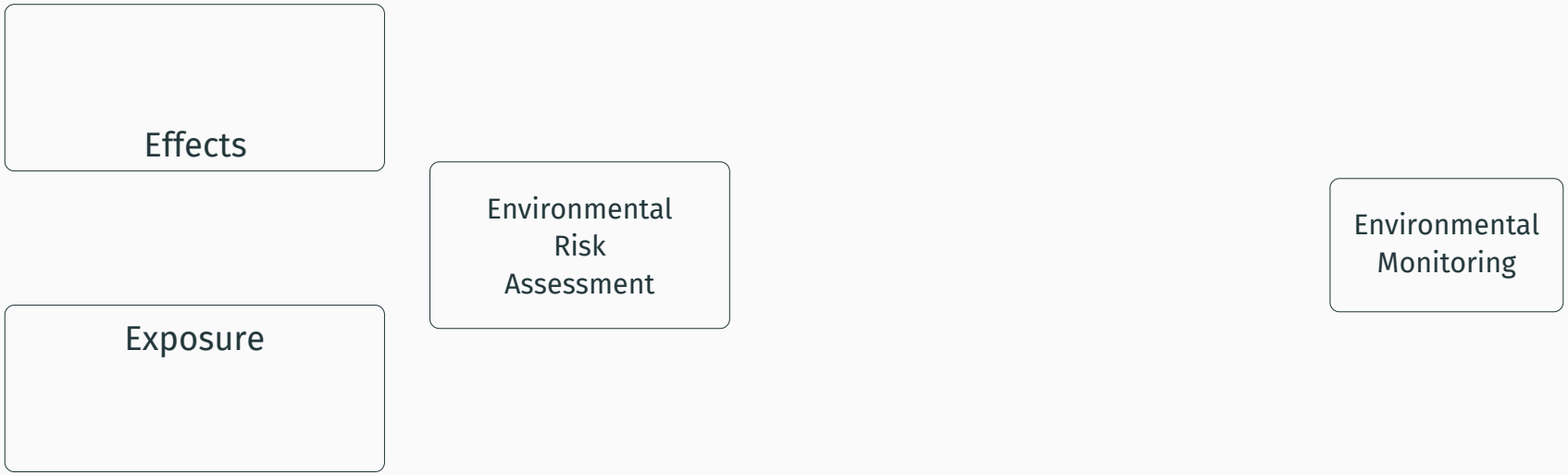
Environmental Risk Assessment

Environmental Monitoring

Environmental Risk Assessment and Monitoring

Plant Protection Products 1107/2009

Water Framework Directive 2000/60/EC



Environmental Risk Assessment and Monitoring

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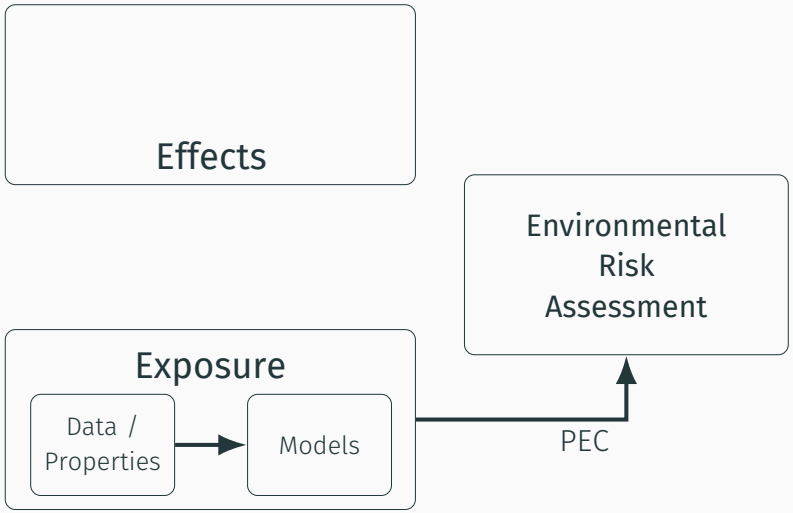

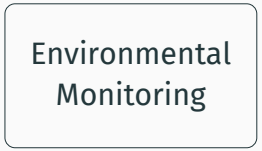

Environmental Risk Assessment and Monitoring

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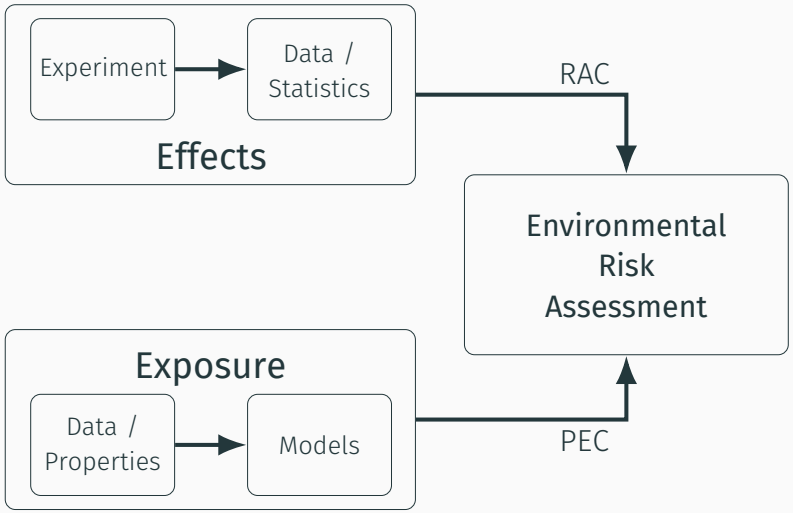
1107/2009



Water Framework Directive
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Environmental Risk Assessment and Monitoring

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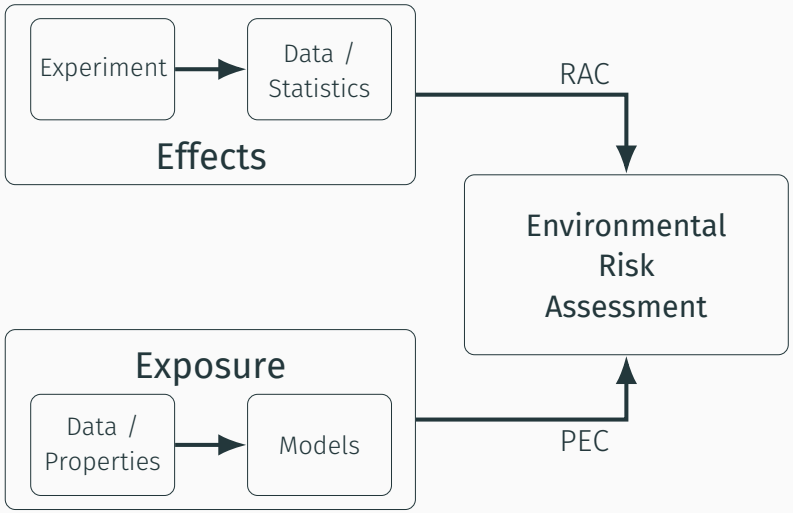

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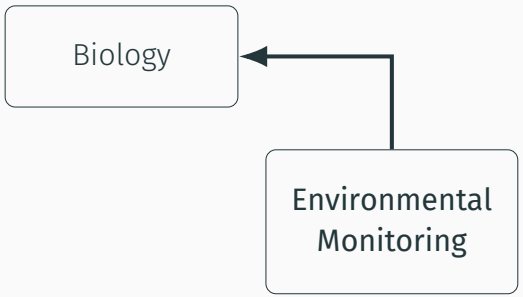

Environmental Risk Assessment and Monitoring

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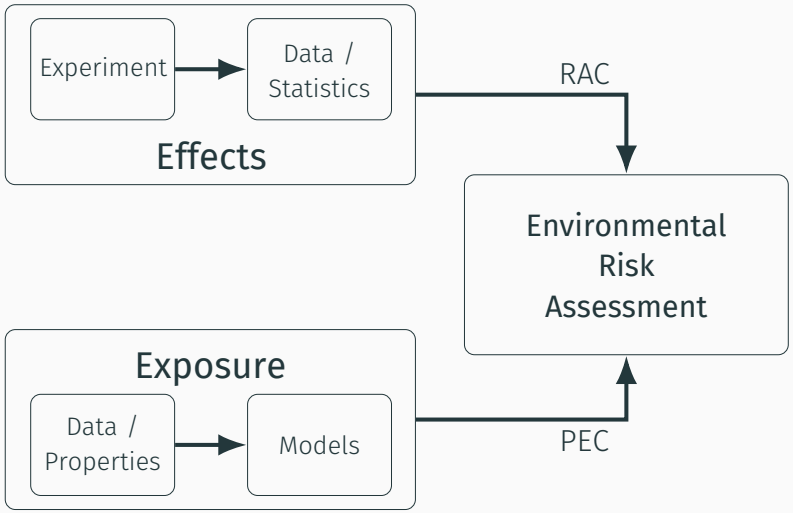

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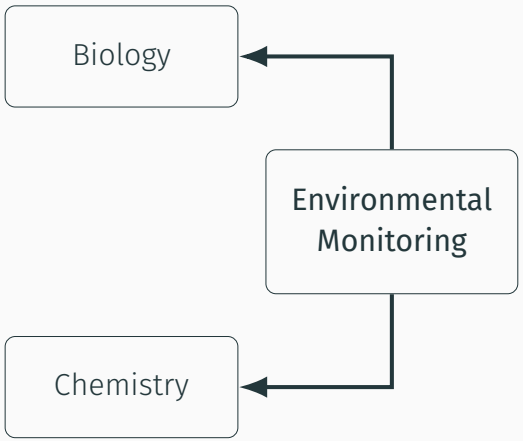

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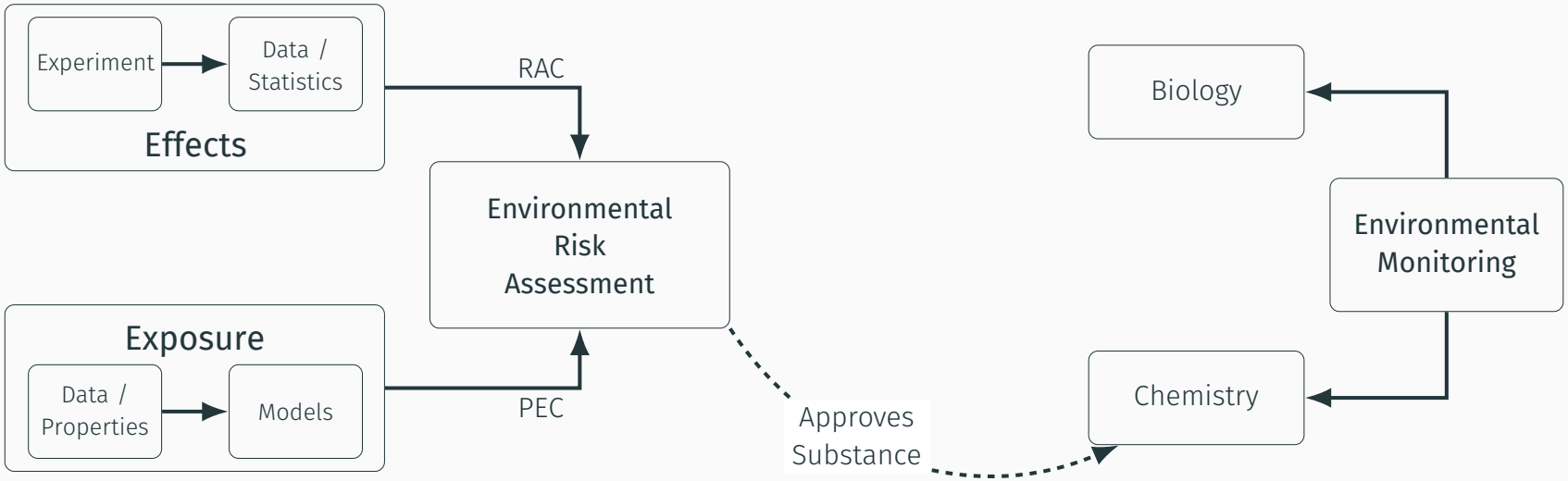

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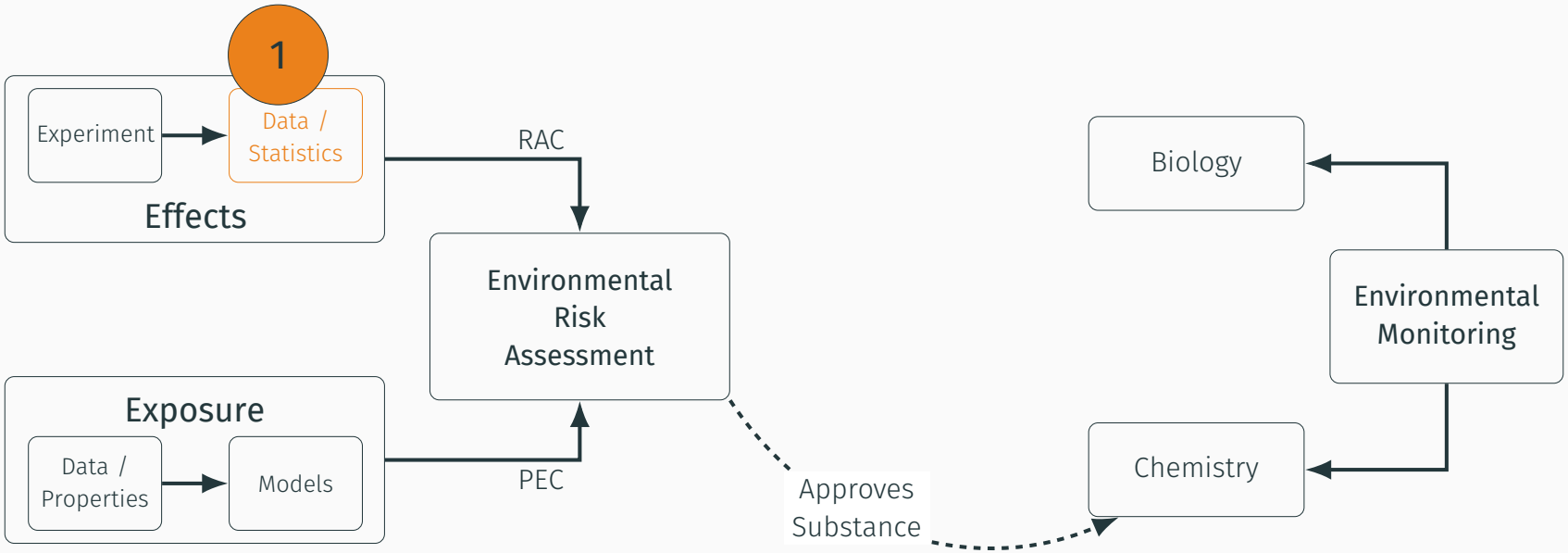
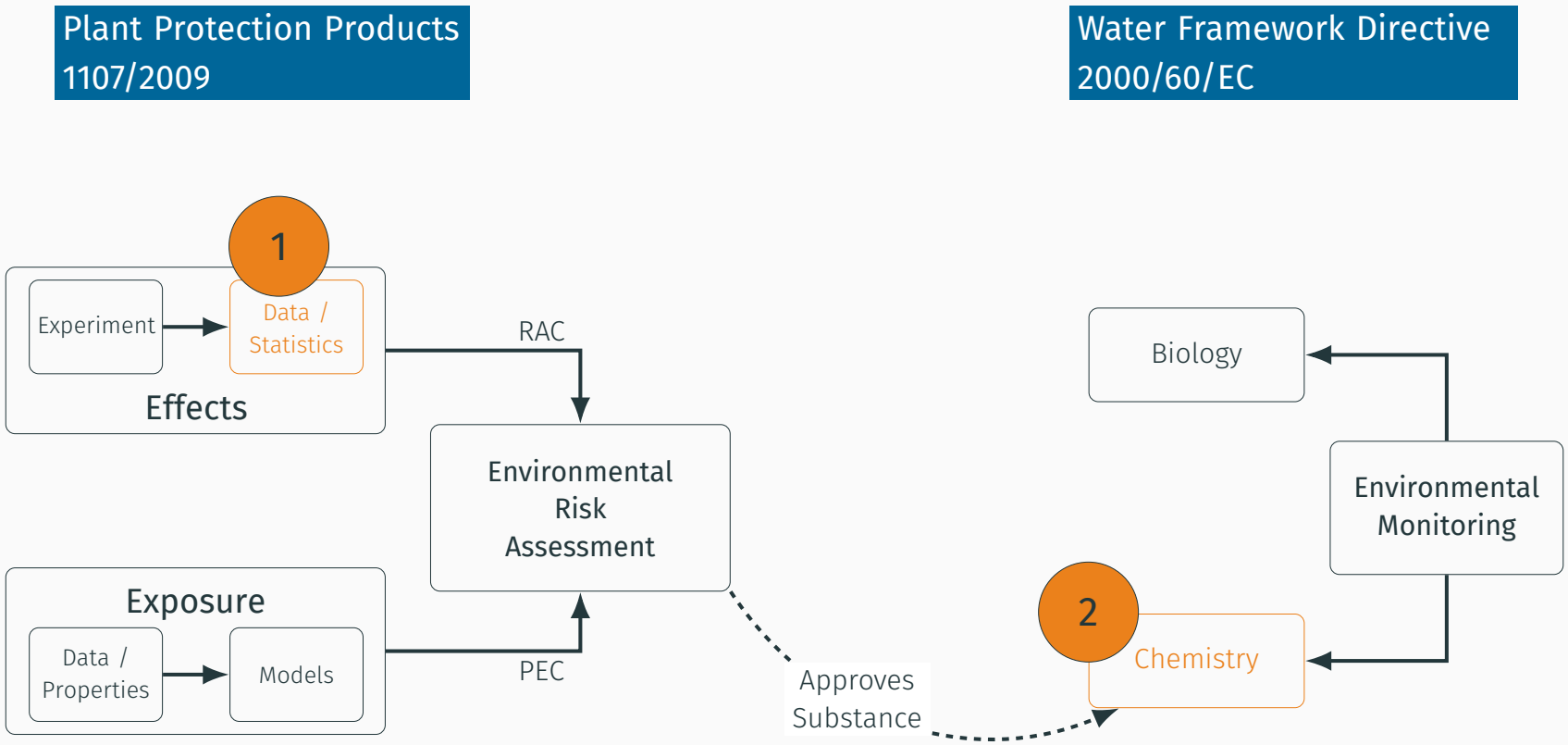


1 Szöcs & Schäfer (2015). “Ecotoxicology is not normal”. ESPR 22(18), 13990–13999.

Environmental Risk Assessment and Monitoring



2 Szöcs, Brinke, Karaoglan & Schäfer (submitted). “Large scale risks from pesticides in small streams”. ES&T.

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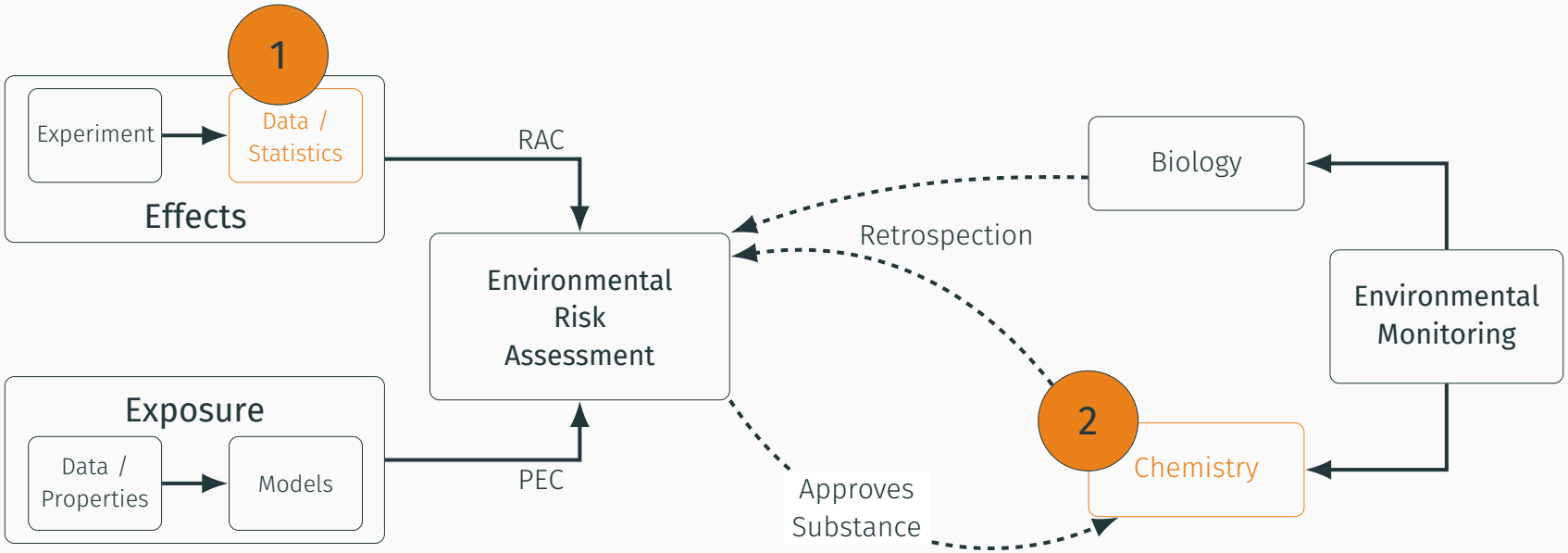

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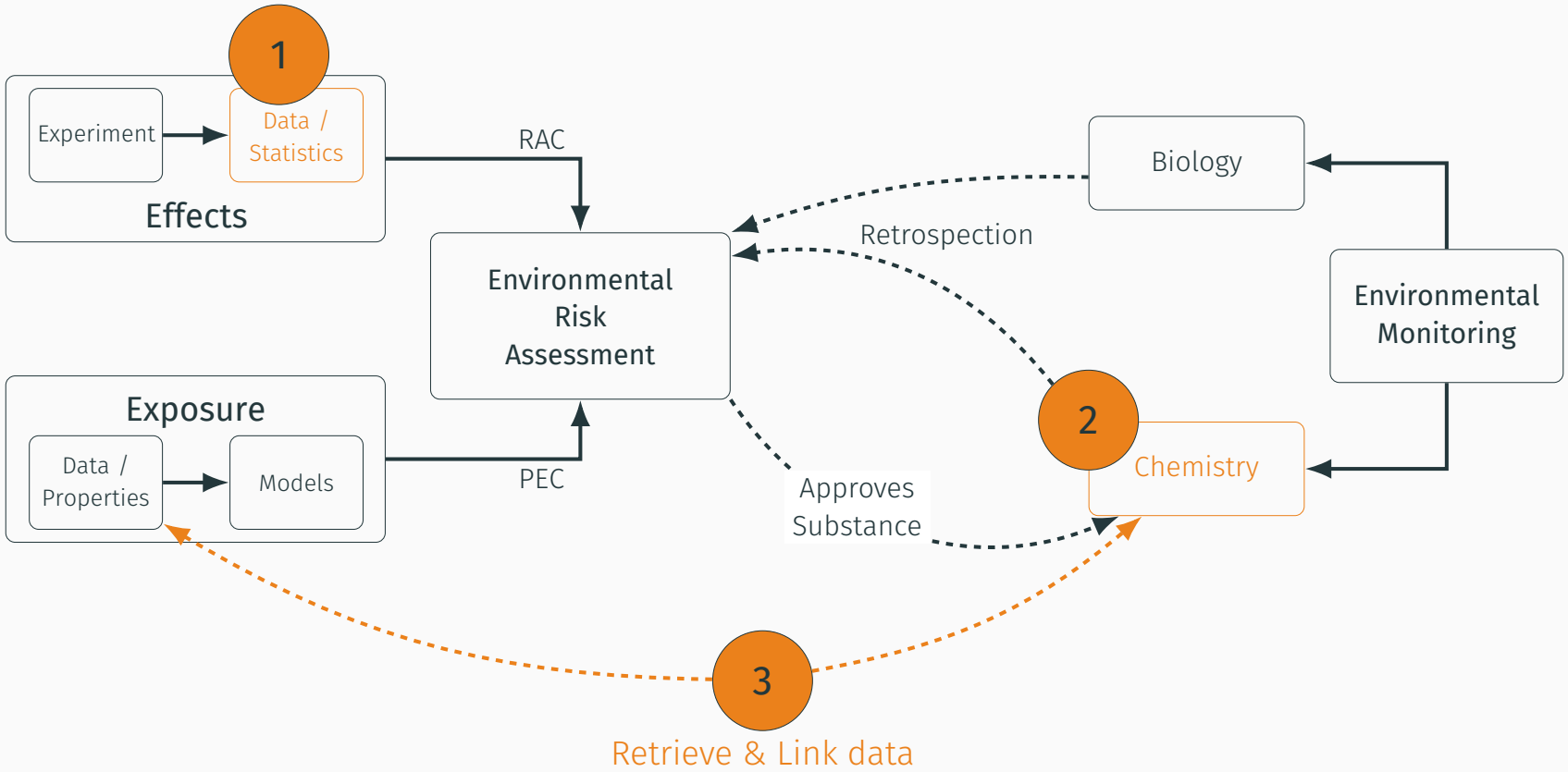
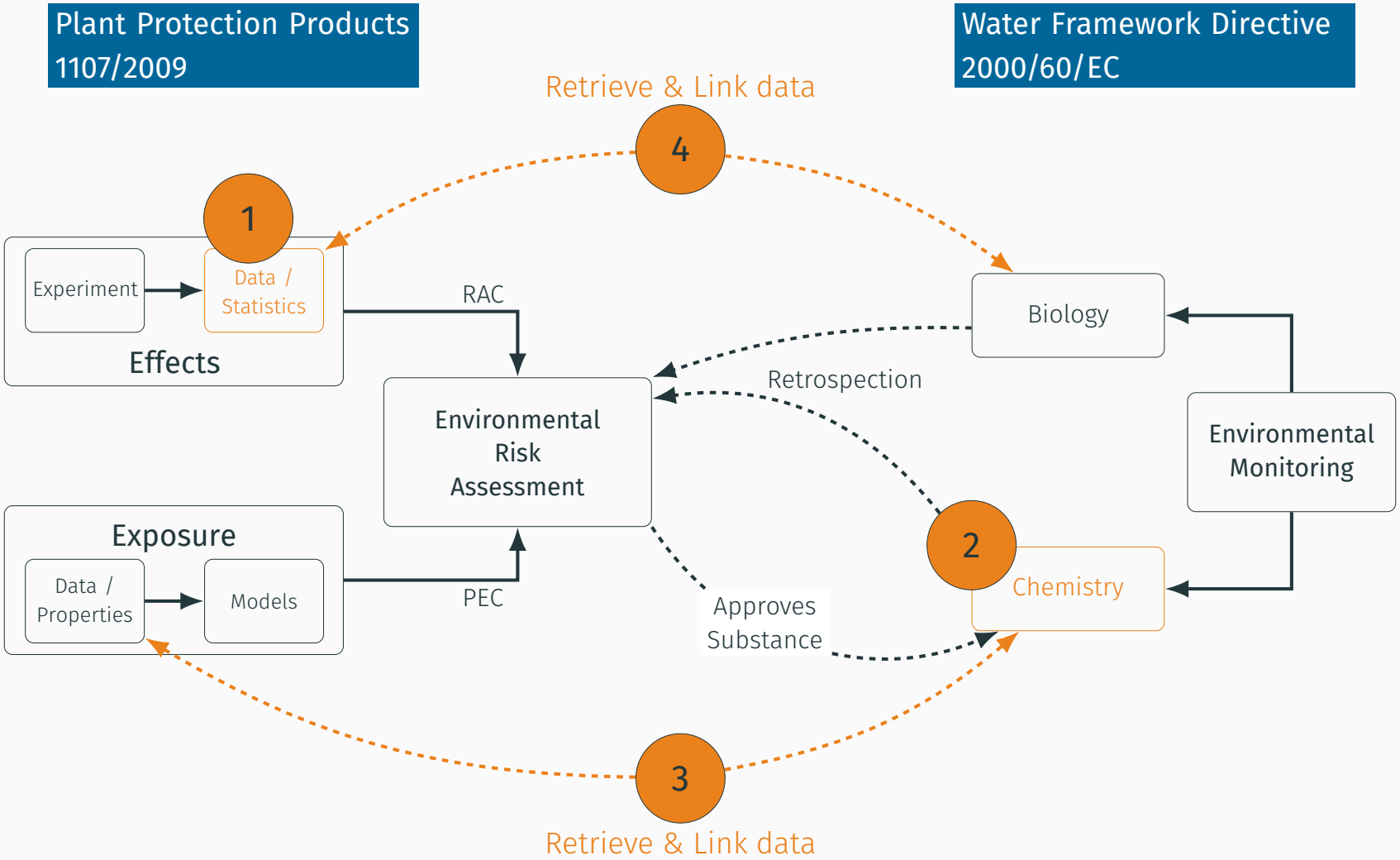


3 Szöcs & Schäfer (accepted). "webchem: An R Package to Retrieve Chemical Information from the Web". JSS.

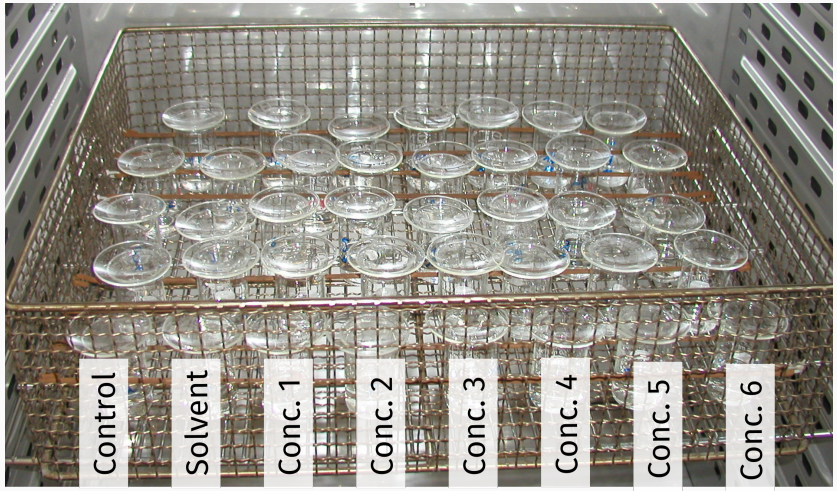
Environmental Risk Assessment and Monitoring



4 Chamberlain & Szöcs (2013). "taxize: taxonomic search and retrieval in R". F1000Research 2(191).

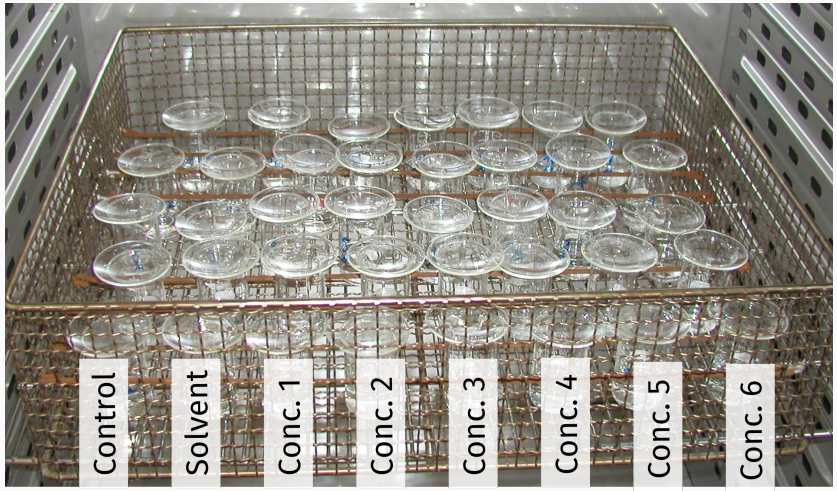
Improving Statistics in ERA

Experiments in Effect Assessment



- Daphnia Test
- Lower Tier
- *”x out of n survived”*

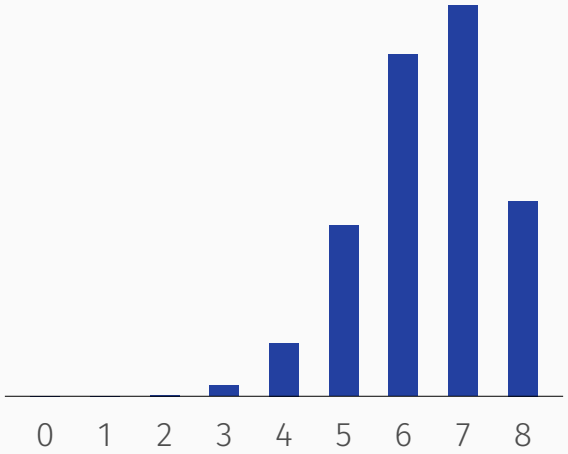
Experiments in Effect Assessment



- Daphnia Test
- Lower Tier
- *”x out of n survived”*

- Mesocosm
- Higher Tier
- *”number of animals”*

Ecotoxicology is not normal



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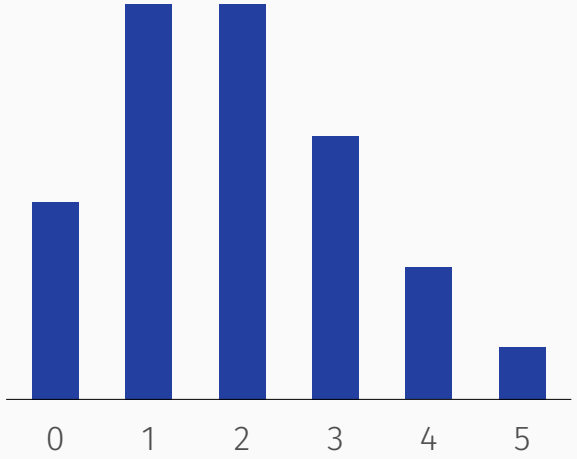

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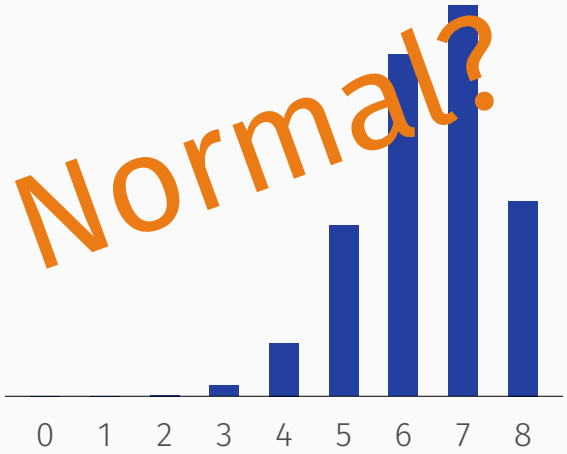

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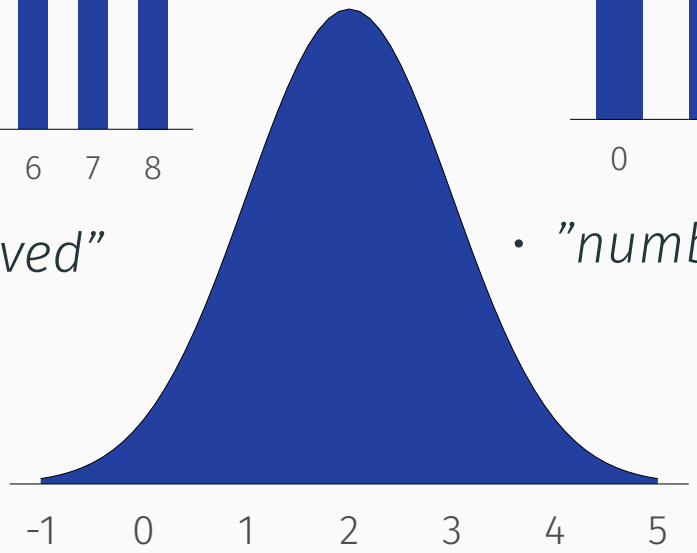

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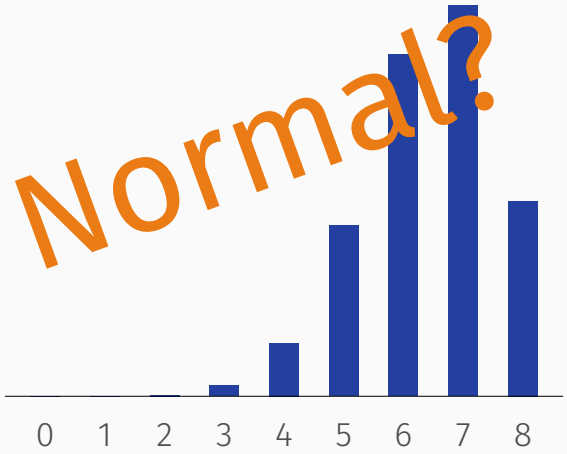
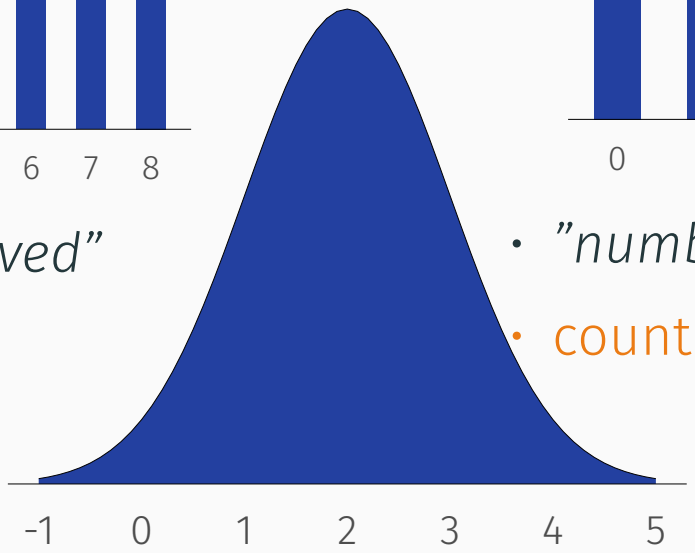


- *"x out of n survived"*
- binomial data



- *"number of animals"*
- count data

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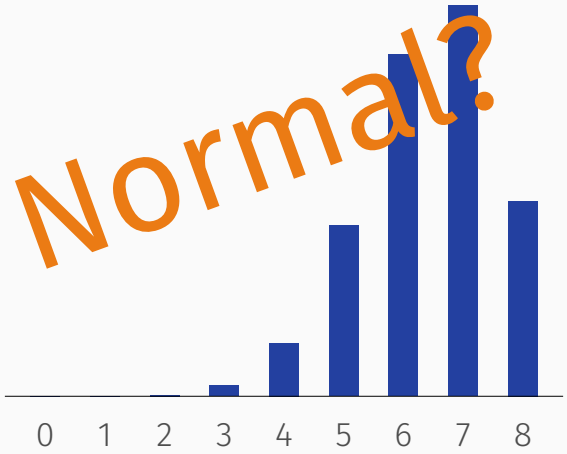

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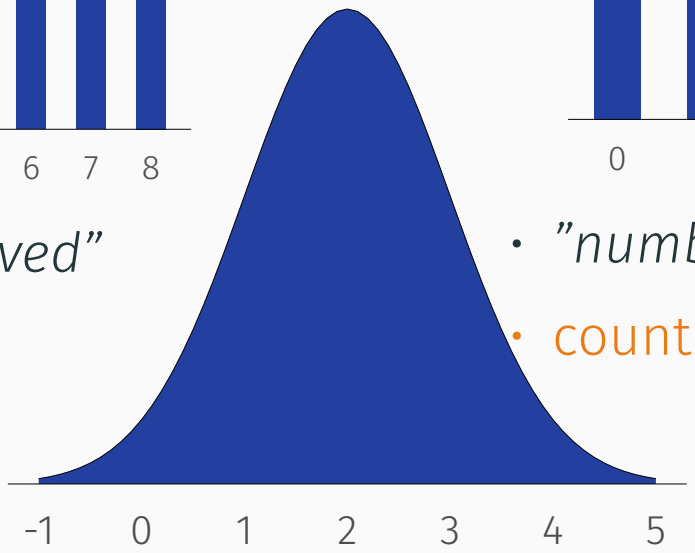

- *"number of animals"*
- count data

- ignore?

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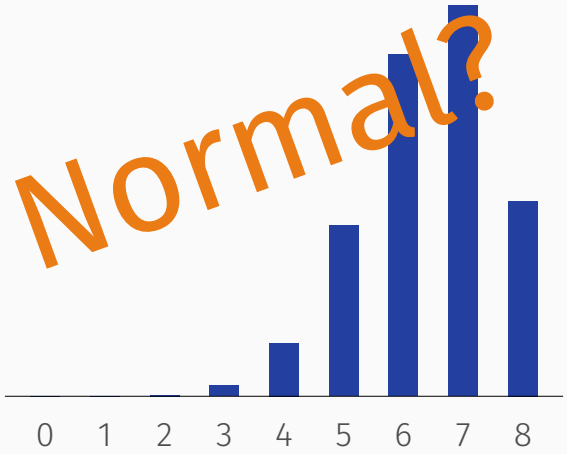

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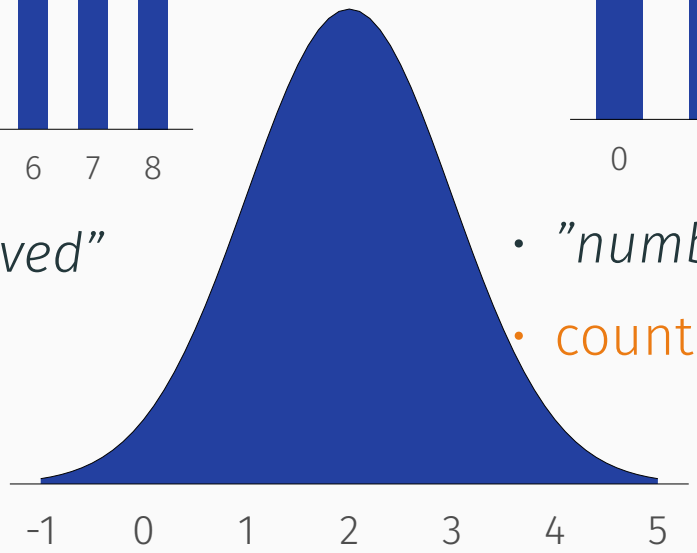

- *"number of animals"*
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- ignore?
- transform?

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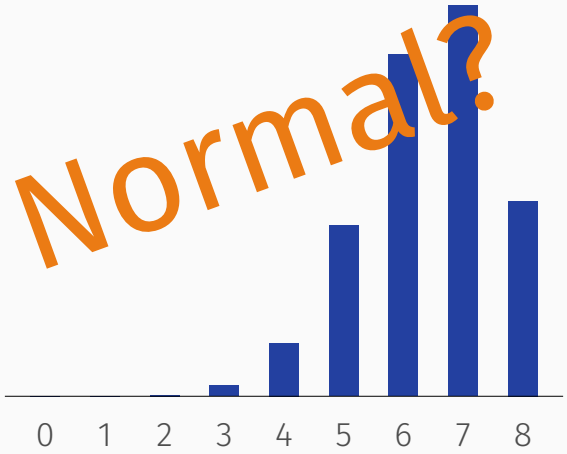

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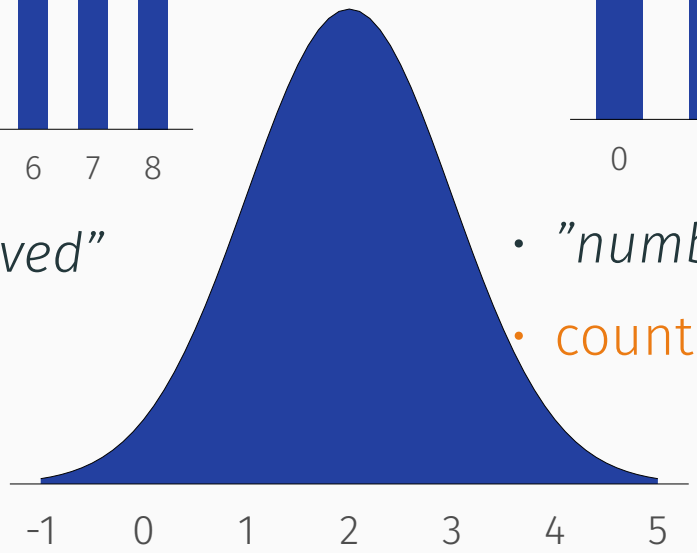

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- ignore?
- transform?
- non-parametric?

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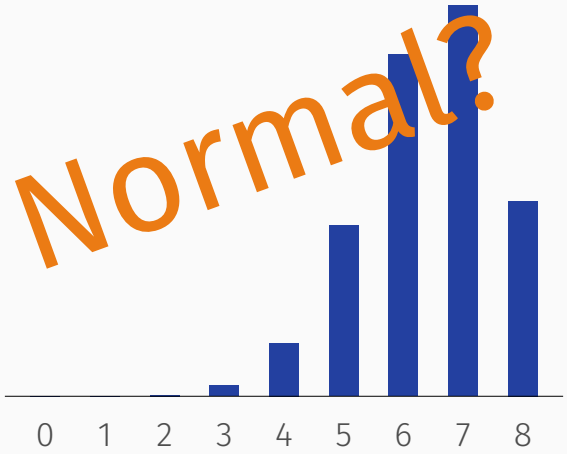

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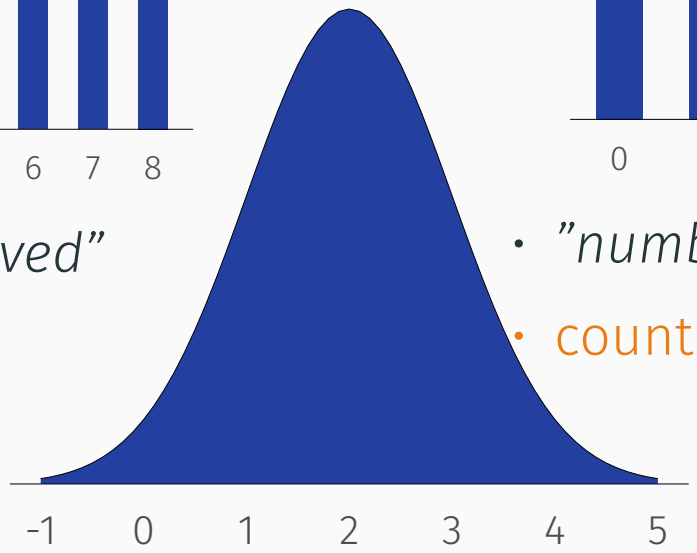

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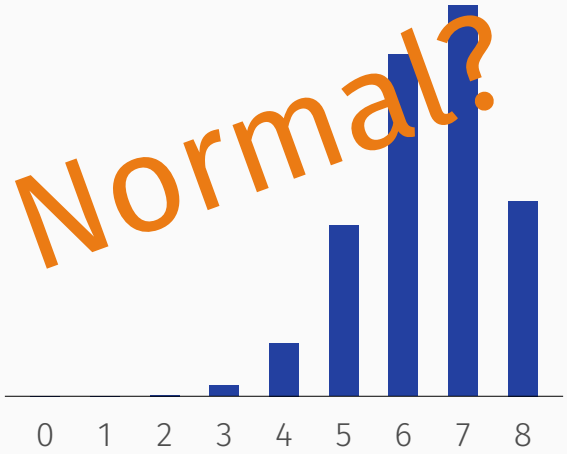

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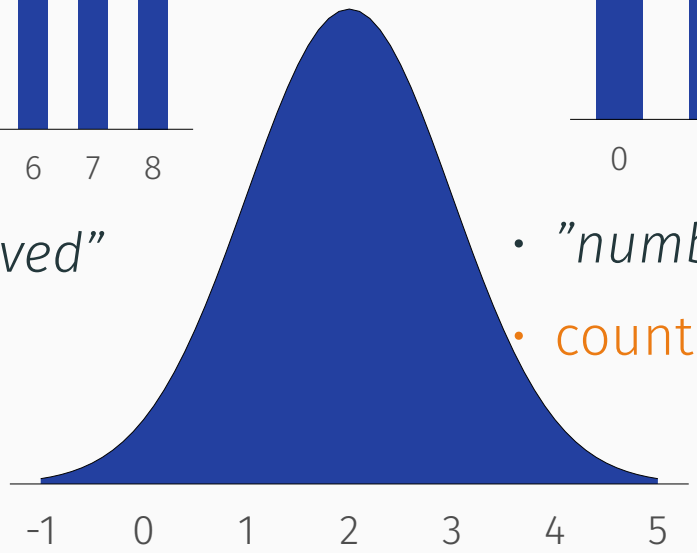

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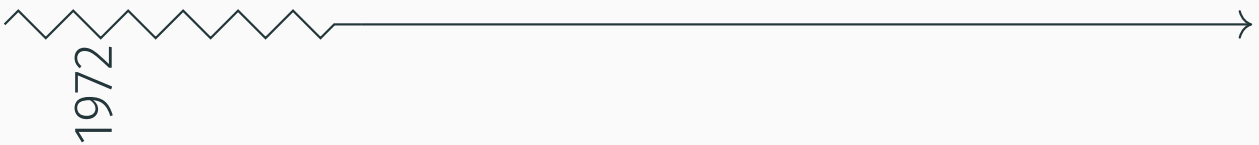
A brief history of GLM (uncomprehensive) in ecology

J. R. Statist. Soc. A,
(1972), **135**, *Part* 3, p. 370

Generalized Linear Models

By J. A. NELDER and R. W. M. WEDDERBURN

Rothamsted Experimental Station, Harpenden, Herts



A brief history of GLM (uncomprehensive) in ecology

Ecology, 88(11), 2007, pp. 2766–2772

QUASI-POISSON VS. NEGATIVE BINOMIAL REGRESSION: HOW SHOULD WE MODEL OVERDISPERSED COUNT DATA?

JAY M. VER HOEF[1] AND PETER L. BOVENG

National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way NE, Building 4, Seattle, Washington 98115-6349 USA

A brief history of GLM (uncomprehensive) in ecology

Methods in Ecology and Evolution

British Ecological Society

Methods in Ecology & Evolution doi: 10.1111/j.2041-210X.2010.00021.x

Do not log-transform count data

Robert B. O'Hara[1]* and D. Johan Kotze[2]

[1]*Biodiversity and Climate Research Centre, Senckenberganlage 25, D-60325 Frankfurt am Main, Germany and*
[2]*Department of Environmental Sciences, PO Box 65, University of Helsinki, Helsinki FI-00014, Finland*

A brief history of GLM (uncomprehensive) in ecology

Ecology, 92(1), 2011, pp. 3–10

The arcsine is asinine: the analysis of proportions in ecology

David I. Warton[1,2,3] and Francis K. C. Hui[1]

[1]*School of Mathematics and Statistics, The University of New South Wales, Sydney, NSW 2052 Australia*
[2]*Evolution and Ecology Research Centre, The University of New South Wales, Sydney, NSW 2052 Australia*

A brief history of GLM (uncomprehensive) in ecology

Methods in Ecology and Evolution

British Ecological Society

Methods in Ecology and Evolution doi: 10.1111/j.2041-210X.2011.00127.x

Distance-based multivariate analyses confound location and dispersion effects

David I. Warton[1]*, Stephen T. Wright[1] and Yi Wang[1,2]

[1]*School of Mathematics and Statistics and Evolution & Ecology Research Centre; and* [2]*School of Computer Science and Engineering, The University of New South Wales, NSW 2052, Australia*

A brief history of GLM (uncomprehensive) in ecology

Ecotoxicology
DOI 10.1007/s10646-015-1421-0

Analysing chemical-induced changes in macroinvertebrate communities in aquatic mesocosm experiments: a comparison of methods

Eduard Szöcs · Paul J. Van den Brink · Laurent Lagadic · Thierry Caquet · Marc Roucaute · Arnaud Auber · Yannick Bayona · Matthias Liess · Peter Ebke · Alessio Ippolito · Cajo J. F. ter Braak · Theo C. M. Brock · Ralf B. Schäfer

A brief history of GLM (uncomprehensive) in ecology

Environ Sci Pollut Res
DOI 10.1007/s11356-015-4579-3

RESEARCH ARTICLE

Ecotoxicology is not normal

A comparison of statistical approaches for analysis of count and proportion data in ecotoxicology

Eduard Szöcs[1] · Ralf B. Schäfer[1]

A simulation study

Statistical Power is unacceptably low

GLM can do better

What we learned

Where are we today?

Where are we today?

Methods in Ecology and Evolution

British Ecological Society

Methods in Ecology and Evolution 2015, **6,** 828–835 doi: 10.1111/2041-210X.12386

For testing the significance of regression coefficients, go ahead and log-transform count data

Anthony R. Ives*

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

Where are we today?

Methods in Ecology and Evolution

British Ecological Society

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 Lyons[2], Jakub Stoklosa[1] and Anthony R. Ives[3]

[1]*School of Mathematics and Statistics and Evolution & Ecology Research Centre, University of New South Wales, NSW 2052, Australia;* [2]*School of Biological, Earth and Environmental Sciences, University of New South Wales, NSW 2052, Australia; and* [3]*Department of Zoology, University of Wisconsin-Madison, Madison, WI 53706, USA*

Where are we today?

Three points to consider ...

1. Choose your model based on data properties
2. Fix Type I errors by resampling
3. Models that better fit the data have better power properties

Warton, D.I., Lyons, M., Stoklosa, J., Ives, A.R., 2016. Three points to consider when choosing a LM or GLM test for count data. Methods in Ecology and Evolution 7, 882–890.

Exploring Monitoring Data for ERA

Environmental Monitoring

Overview on data compiled

Thresholds

Statistics with chemical measurements

Dynamics

Risks

Check: What did go wrong with Neonics during ERA? Exposure wromg? Effect wrong (e.g. did not consider sensitive species)? => Quite sure that Effect assessment missed it... => show SSD, highlighting standard test species (from EPA) * old guidance document did not enforce insect. * new one (from 2013) enforces additional insect data

RAC is landscape dependend (=> exposure?)

Example for power (experimental setup)

What we learned

Solutions for Linking Data in ERA

Biologists & Chemists face the same problems

Names

Osmia rufa, Osmia bicornis, Osmia ruffa, Osmia unilandauis, Osmia spec.

Chlorpyrifos, Chlorpyriphos, Chlorphyrifos, Chlorpyrifos-ethyl, Chlorpypifot

Biologists & Chemists face the same problems

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Osmia rufa, Osmia bicornis, Osmia ruffa, Osmia unilandauis, Osmia spec.

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Hierarchies

Hymenoptera/ Apoidea/ Megachilidae/ Osmia/ rufa

organophospate, ester, insecticide

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Names

Osmia rufa, Osmia bicornis, Osmia ruffa, Osmia unilandauis, Osmia spec.

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Hierarchies

Hymenoptera/ Apoidea/ Megachilidae/ Osmia/ rufa

organophospate, ester, insecticide

Traits / Properties

Wing length, Mass, Season

Mass, K_{OW}, LC_{50}

Biologists & Chemists face the same problems

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Hymenoptera/ Apoidea/ Megachilidae/ Osmia/ rufa

organophospate, ester, insecticide

Traits / Properties

Wing length, Mass, Season

Mass, K_{OW}, LC_{50}

Identifiers

NCBI, ITIS, EOL, ...

2921-88-2, Clc1c(OP(=S)[...], InChI=1S/C9H11C[...], SBPBAQFW[...], CSID,...

Biologists & Chemists face the same problems

Names

Osmia rufa, Osmia bicornis, Osmia ruffa, Osmia unilandauis, Osmia spec.	Chlorpyrifos, Chlorpyriphos, Chlorphyrifos, Chlorpyrifos-ethyl, Chlorpypifot

Hierarchies

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

Traits / Properties

Wing length, Mass, Season	Mass, K_{OW}, LC_{50}

Identifiers

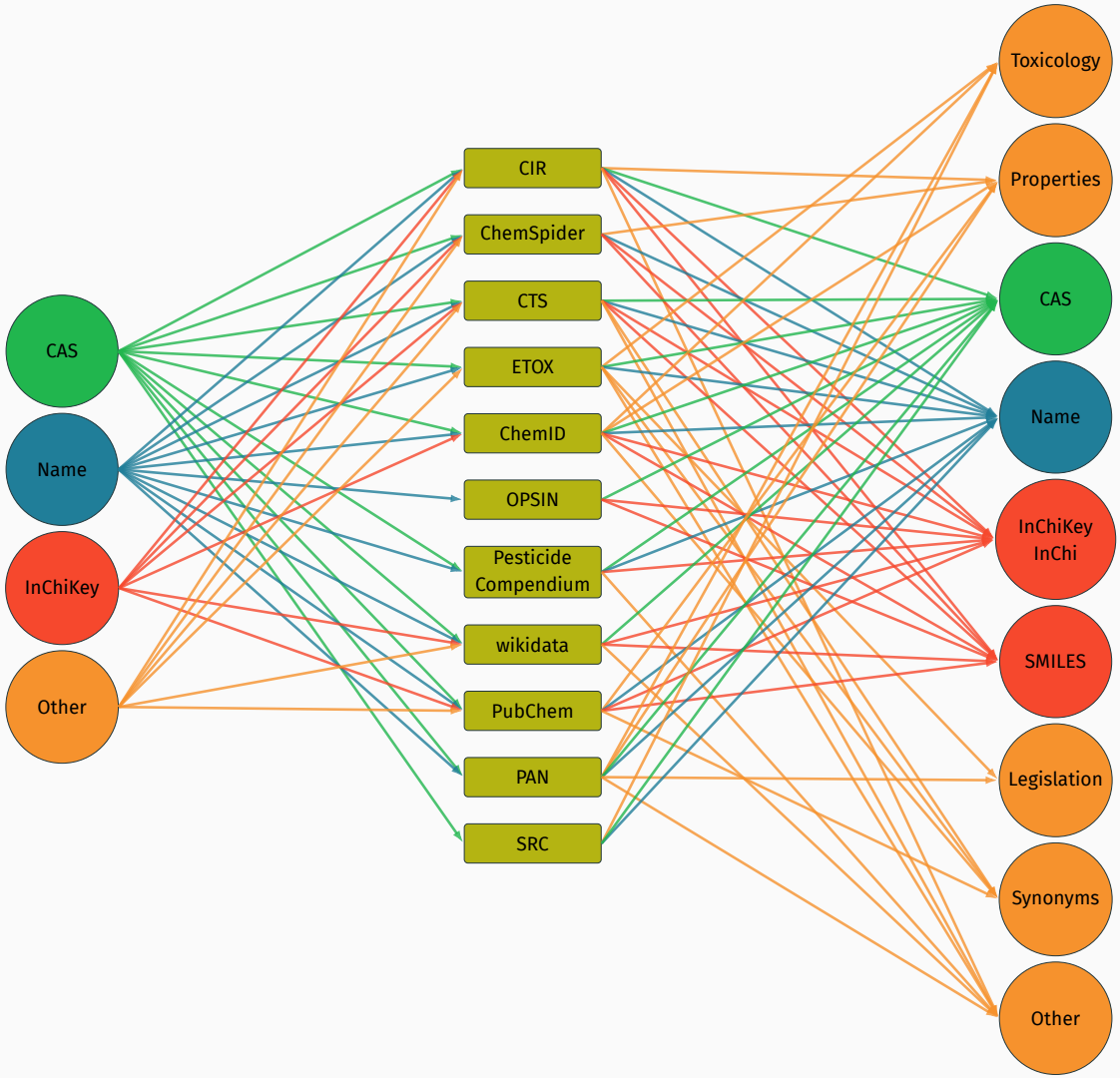
NCBI, ITIS, EOL, ...	2921-88-2, Clc1c(OP(=S)[...], InChI=1S/C9H11C[...], SBPBAQFW[...], CSID,...

Amount of data

2993 taxa	489 pesticides (+ 590 other organics)

Instead of wasting time...

... use webchem!



Münch et al. (2016). DoOR 2.0 - Comprehensive Mapping of Drosophila melanogaster Odorant Responses. Scientific Reports 6, 21841

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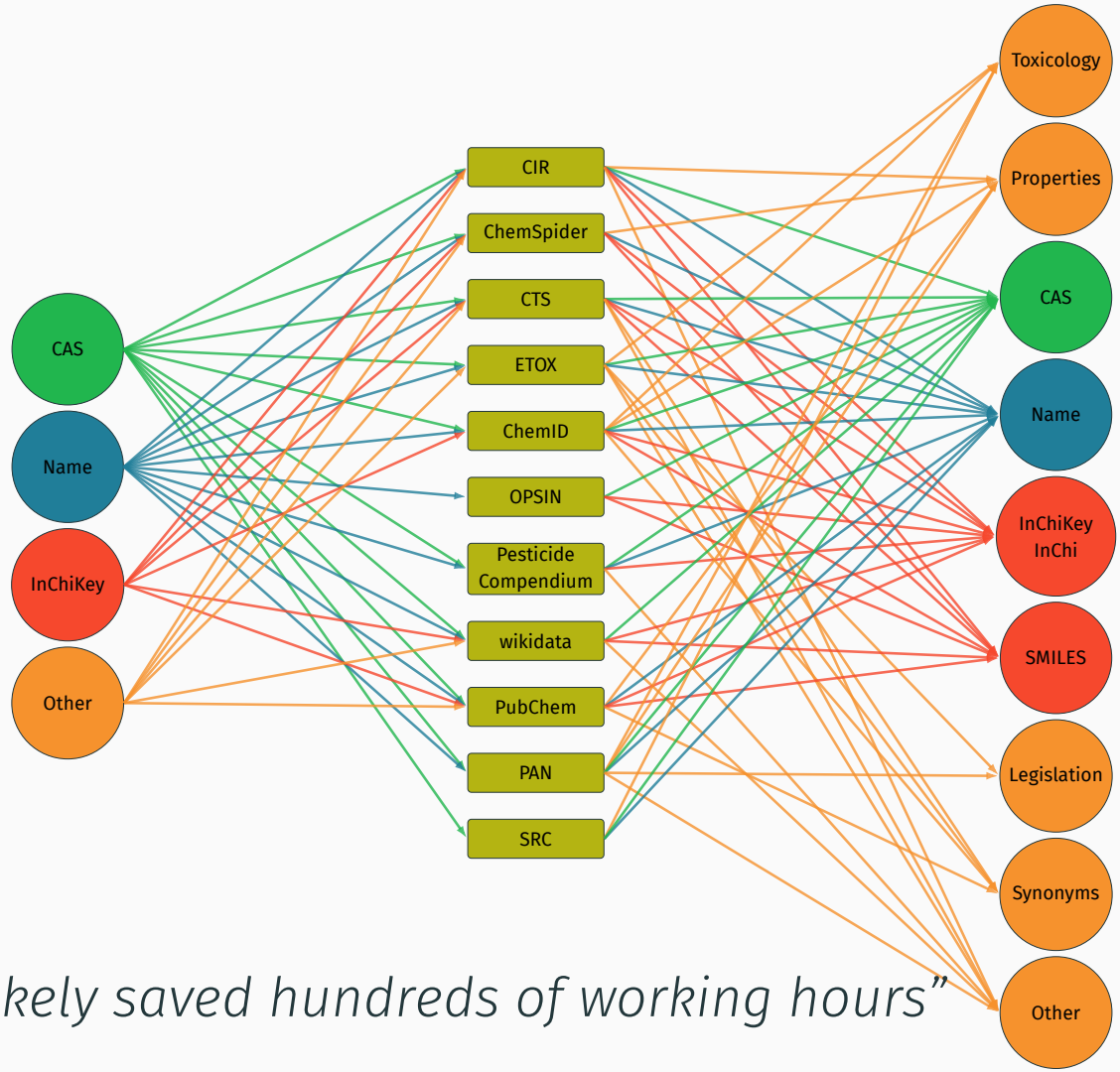

"webchem ...likely saved hundreds of working hours"

Münch et al. (2016). DoOR 2.0 - Comprehensive Mapping of Drosophila melanogaster Odorant Responses. Scientific Reports 6, 21841

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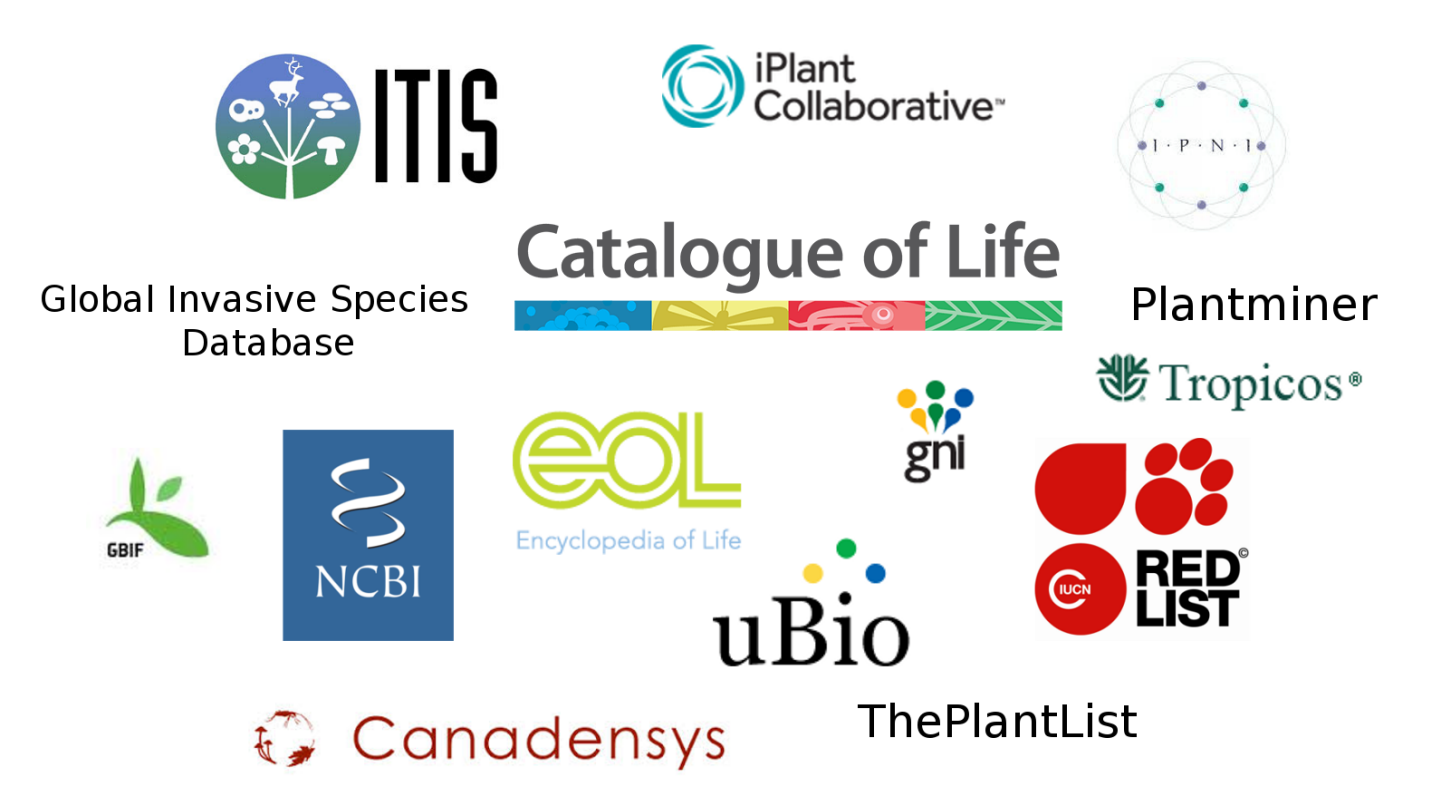

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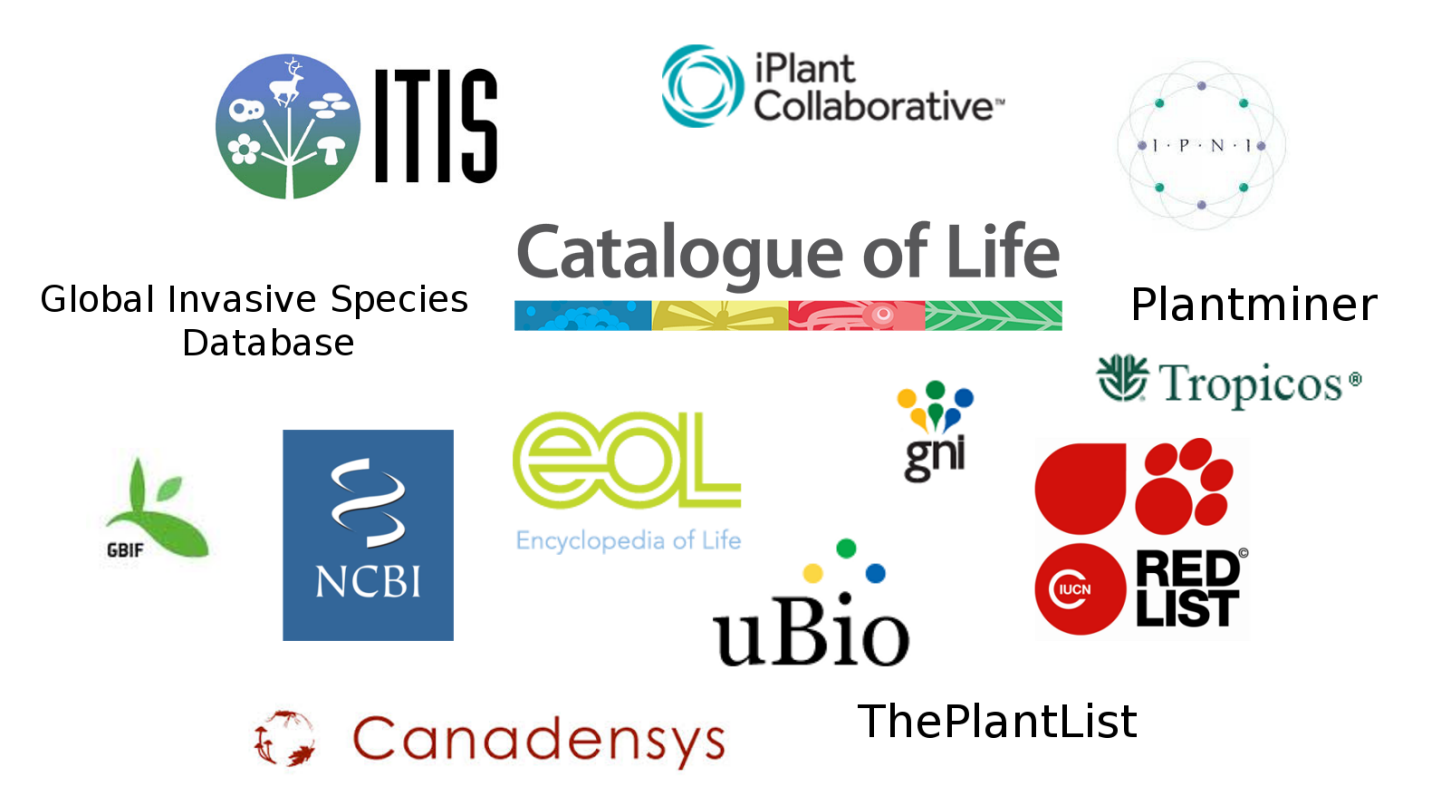

"Days of searching done during my morning coffee. Amazing. taxize."

Dr. Susan E. Johnston, University of Edinburgh. On twitter.

Recap

What we learned

✓Improving Statistics in ERA

- Change your model, not your data
- Ultimately ban NOEC
- Take LOQ into account

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- Agricultural small streams at risk
- Neonicotinoids
- Feedback 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 Environmental Risk Assessment

Eduard Szöcs

http://edild.github.io/

@EduardSzoecs

https://github.com/edild/phd_defense

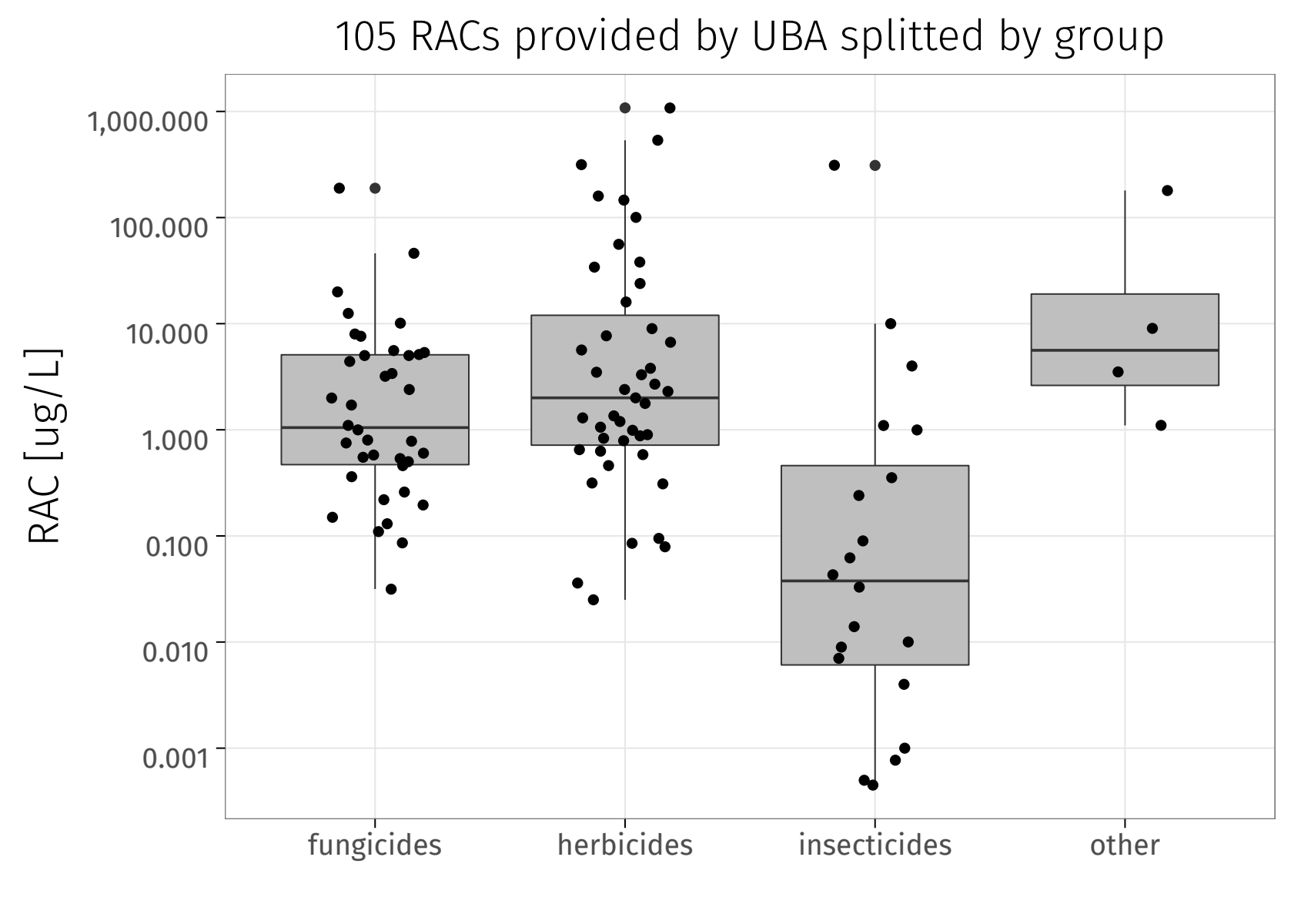
https://github.com/edild/phd_thesis

Statistics?

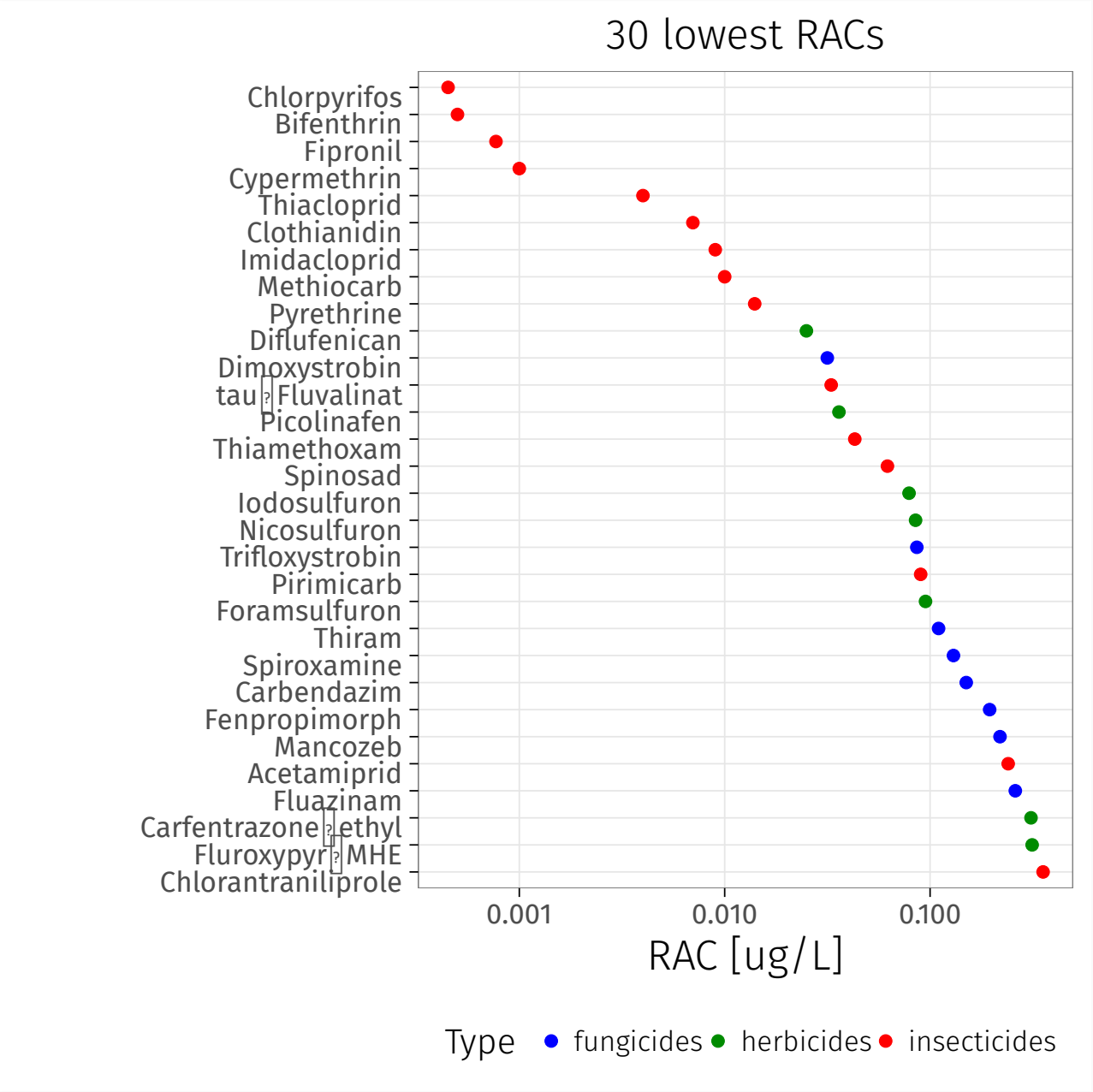
ZAGA what...?

Comparison with Stehle / Knauer?

RACs by Type


105 RACs provided by UBA splitted by group
RAC [ug/L]
1,000.000
100.000
10.000
1.000
0.100
0.010
0.001
fungicides
herbicides
insecticides
other

RACs by Compound



Mixtures => mainly one compound

TU Grafik

Simulation are powerful!

Example for desgin of dose-response-models

ecology / biota?