# Can ecosystem models improve ecological effect assessments and water quality criteria-setting?

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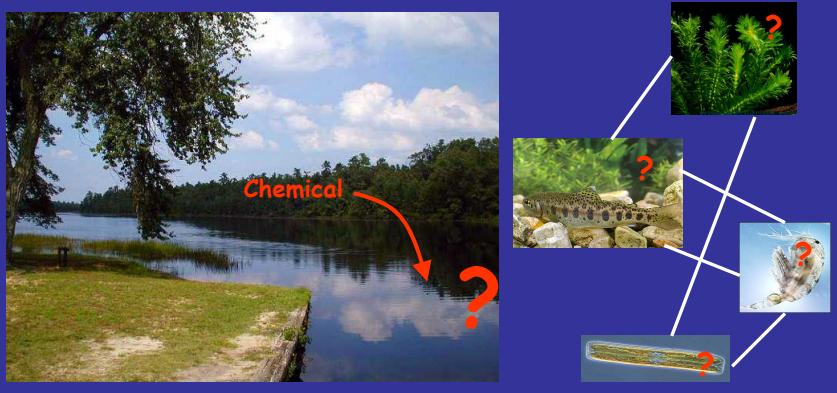
## Scope

- ✓ ecological effects assessment: effect?
- ✓ water quality criteria-setting: concentration ?

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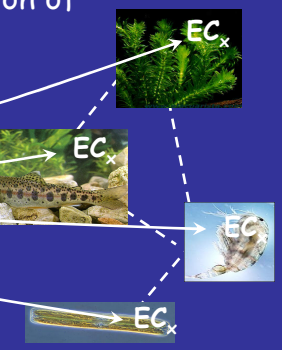
# Problem formulation

- ✓ Current solution: based on single species toxicity = based on **single species sensitivities** (e.g. SSD)
- ✓ proof from large-scale studies:
- ✓ effects on higher levels = function of
  - single species sensitivities
  - AND ecological interactions






# Goals

- ✓ A possible alternative to current approaches:
- ✓ Ecosystem models:
  - ✓ecological interactions
  - ✓single species sensitivities
- ✓ **Can we use these models to:**
  - ✓**predict effects on populations within their ecosystem ?**
    - → **ecological effects assessment**
  - ✓**derive 'safe' concentrations for chemicals ?**
    - → **water quality criteria-setting**

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# Method: comparison

- ✓ **Literature-reported** population- and ecosystem- NOECs observed in experimental ecosystems

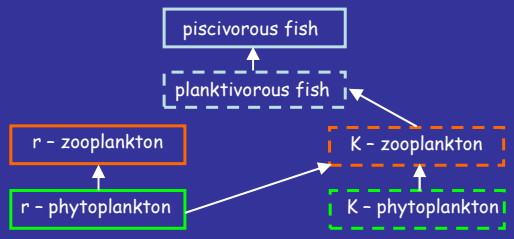
- ✓ **Predictions** by ecosystem models of population- and ecosystem-NOECs for those systems

  - **If predicted NOEC = observed NOEC: accurate**
  - **If predicted value NOEC < observed NOEC: overprotective**
  - **If predicted NOEC > observed NOEC : underprotective**



# Method: example: Atrazine

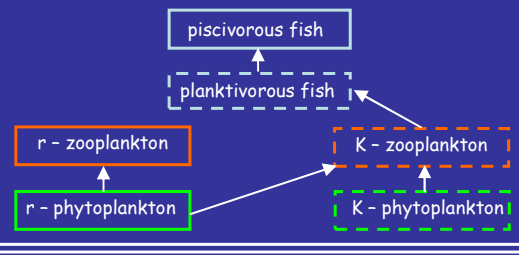
1. Literature: ecosystem-level testing: e.g. Denoyelles et al., 1982
2. What are the dominating species in this experiment?
   - ✓ phytoplankton: Cryptomonas sp., Mallomonas sp., Peridinium sp.
   - ✓ zooplankton: Keratella quadrata, Diaphanosoma brachyurum, Tropocyclops mexicanus
   - ✓ fish: bluegill sunfish, predator (N.S.)
3. Grouping of species in model populations




4. Single-species toxicity data: mortality / growth – $EC_{50}$s

# Method: example: Atrazine

3. Grouping of species into model populations + links




4. Single-species toxicity data: $EC_{50}$s

Ecosystem model

- food web model
- toxic effect sub-model: logistic function
- abiotic processes



# Method: example: Atrazine

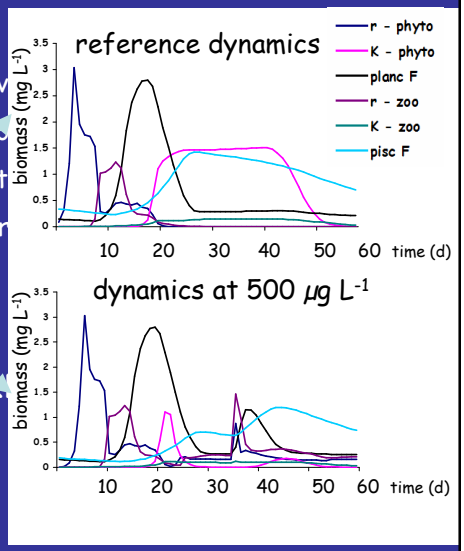
Ecosystem model

- food web model
- toxic effect sub-model: logistic function
- abiotic processes

+

Experiment specifications

- duration = 60 d
- 20 and 500 µg $L^{-1}$

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# Results: example: Atrazine

| population | $RD_{20}$ (%) | $RD_{500}$ (%) | population-NOEC |
|---|---|---|---|
| r - phytoplankton | 9.2 | 1.20E+04 | |
| K - phytoplankton | 2.5 | -90 | |
| planktivorous fish | <1 | 13 | |
| r - zooplankton | <1 | 1.40E+03 | |
| K - zooplankton | <1 | -22 | |
| piscivorous fish | <1 | 17 | |

- ecosystem – NOEC = 20 $\mu g\ L^{-1}$
- accurate for all populations



# Results I

# more substances

# population - NOECs

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# Results: population-NOECs

| study | chemical | fraction of population-NOECs: accurate | overprotective | underprotective |
|---|---|---|---|---|
| 1 | diflubenzuron | 0.9 | 0 | 0.1 |
| 2 | atrazine | 1 | 0 | 0 |
| 3 | esfenvalerate | 0.6 | 0.4 | 0 |
| 4 | esfenvalerate | 0.8 | 0.2 | 0 |
| 5 | metribuzin | 0.4 | 0.4 | 0.2 |
| 6 | azinphos-methyl | 1 | 0 | 0 |
| 7 | fenthion | 0.6 | 0.4 | 0 |
| 8 | azinphos-methyl | 1 | 0 | 0 |
| 9 | atrazine | 0 | 0.6 | 0.4 |
| 10 | atrazine | 1 | 0 | 0 |
| 11 | linuron | 0 | 0.8 | 0.2 |
| 12 | copper | 1 | 0 | 0 |



# Results: population-NOECs

- ✓ On average:
  - 68% accurate population-NOECs
  - 22% overprotective population-NOECs
  - 10% underprotective
- ✓ If low fraction of accurate population-NOECs
  - higher fraction **overprotective** population-NOECs
  - rather than higher fraction **underprotective** population-NOECs
- ✓ Implications for water quality criteria-setting?

→ ecosystem-NOECs..

# Results II

# more substances

# ecosystem - NOECs



# Results: ecosystem-NOECs

✓ **No underprotective ecosystem-NOECs**

| | | population-NOECs | | | ecosystem-NOECs | |
|---|---|---|---|---|---|---|
| study | chemical | accurate | overprotective | underprotective | accurate | overprotective |
| 1 | diflubenzuron | 0.9 | 0 | 0.1 | x | |
| 2 | atrazine | 1 | 0 | 0 | x | |
| 3 | esfenvalerate | 0.6 | 0.4 | 0 | x | |
| 4 | esfenvalerate | 0.8 | 0.2 | 0 | x | |
| 5 | metribuzin | 0.4 | 0.4 | 0.2 | | x(factor 10) |
| 6 | azinphos-methyl | 1 | 0 | 0 | x | |
| 7 | fenthion | 0.6 | 0.4 | 0 | x | |
| 8 | azinphos-methyl | 1 | 0 | 0 | x | |
| 9 | atrazine | 0 | 0.6 | 0.4 | | x(factor 20) |
| 10 | atrazine | 1 | 0 | 0 | x | |
| 11 | linuron | 0 | 0.8 | 0.2 | | x(factor 10) |
| 12 | copper | 1 | 0 | 0 | x | |

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# Results: ecosystem-NOECs

- ✓ **Ecosystem-NOECs:**
- ✓ **A loss of accuracy implies increased conservatism ...rather than a loss of protective capacity**



# Conclusions

Can these ecosystem models ***improve*** ecological effects assessments?

literature:

- ✓ single-species tests alone ***can not*** reliably predict effects which ***are*** observed in large-scale studies (Fleeger *et al.*, 2003)

the presented ecosystem models:

- ✓ population-NOECs predicted accurately for 68% of all considered populations

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# Conclusions

Can these ecosystem models ***improve*** water quality criteria-setting?

literature: comparisons $HC_5$-PNEC with experimental ecosystem-NOECs

- ✓ factor 1.5 to 1000 overprotective
  Hose *et al.* (2004); Selck *et al.* (2002)
- ✓ although: not ***always*** protective
  Maltby *et al.* (2005)

ecosystem-NOEC, as predicted by the presented ecosystem models

- ✓ always protective
  - ✓ accurate in 75% of the cases
  - ✓ in 25%: factor 10-20 overprotective



# Conclusions

Can these ecosystem models ***improve*** water quality criteria-setting?

→ ecosystem models can reduce the uncertainty in water quality criteria-setting

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