Challenges in applying the ecosystem services framework to risk assessments of regulated stressors.

Valery E. Forbes

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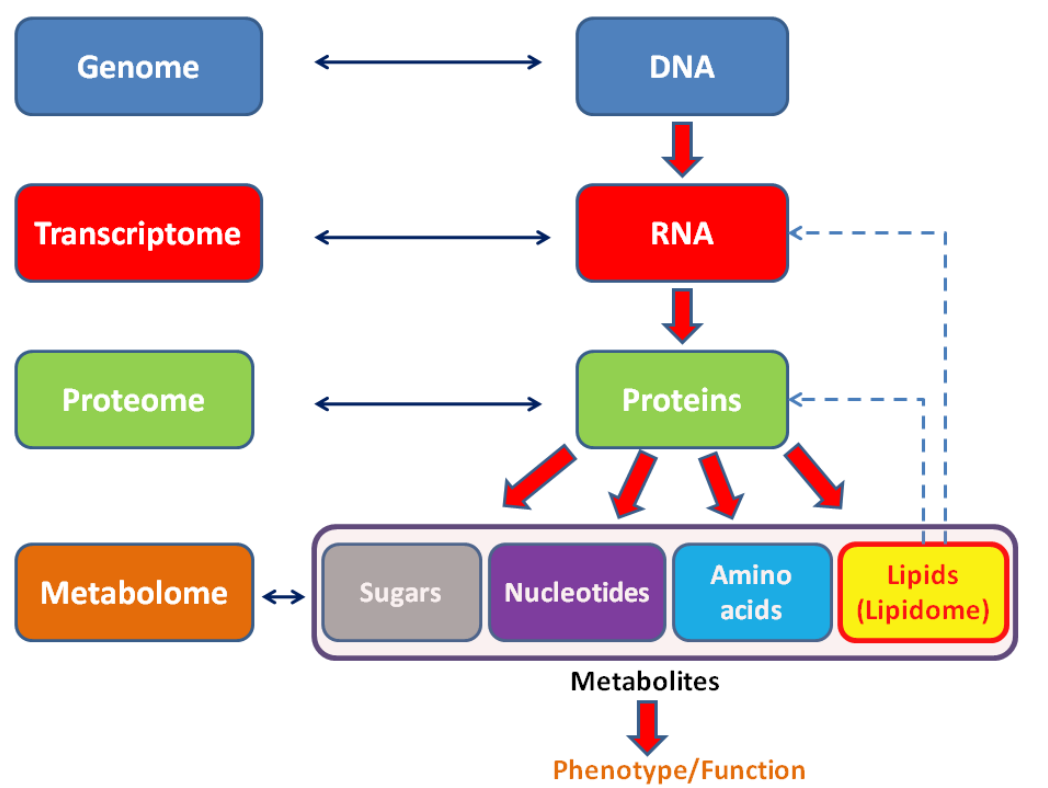
What we measure



What we care about

European Food Safety Authority

EFSA Journal 2010;8(10):1821

SCIENTIFIC OPINION

Scientific Opinion on the development of specific protection goal options for environmental risk assessment of pesticides, in particular in relation to the revision of the Guidance Documents on Aquatic and Terrestrial Ecotoxicology (SANCO/3268/2001 and SANCO/10329/2002)[1]

EFSA Panel on Plant Protection Products and their Residues (PPR)[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

ABSTRACT

General protection goals are stated in European legislation but specific protection goals (SPGs) are not precisely defined. These are however crucial for designing appropriate risk assessment schemes. Here a process for defining SPG options is presented, which uses the ecosystem services approach as an overarching concept and could be used in consultation processes with risk managers and stakeholders. SPGs are defined in 6 dimensions: biological entity, attribute, magnitude of effect, temporal and geographical scale of the effect, and the degree of certainty that the specified level of effect will not be exceeded. SPG options are presented for 7 key drivers (microbes, algae, non target plants (aquatic and terrestrial), aquatic invertebrates, terrestrial non target arthropods including honeybees, terrestrial non-arthropod invertebrates, and vertebrates), covering all ecosystem services which could potentially be affected by the use of pesticides. To ensure ecosystem services, taxa representative for the key drivers identified need to be protected at the population level or higher. However, for aesthetic reasons (cultural ecosystem services) it may be decided to protect vertebrates at the individual level. To protect biodiversity, impacts at least need to be assessed at the scale of the watershed/landscape. The Panel also emphasizes the importance of a tiered approach for risk assessment, the essential linking of exposure and effect assessments in terms of spatial and temporal scales, and the relevance of ecological scenarios for appropriate pesticide risk assessments. It intends to use the presented concepts as input for the dialogue between risk managers and risk assessors during the next steps of the revision of the Ecotoxicology Guidance Documents.

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Development of a framework based on an ecosystem services approach for deriving specific protection goals for environmental risk assessment of pesticides

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STEP 1 List Ecosystem Services (ES)

Starting point:
Millennium Ecosystem Assessment (2005)

STEP 2 Identify **ES potentially affected by pesticides**

STEP 3 Identify **key drivers** (representative taxa or functional groups) for the ES

STEP 4 Develop **specific protection goals (SPG)**: identify **"6 dimensions"** for each key driver / ES combination

ES / key driver overview table (EFSA Panel on Plant Protection Products and their Residues, 2010)

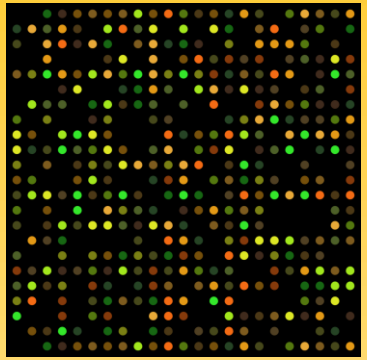
MEA category	Ecosystem service	In Crop	Off Crop				Potentially impacted by pesticides (direct or indirect effects)	Key drivers
			Edge of field	More remote terrestrial areas (e.g. hedges)	Small edge-of-field surface waters	Large surface waters + wetlands + marine ecosystems		
Provisioning services	Food	+++	+	++	+	+++	Yes	crop species, cattle, small game and other consumable vertebrates, fungi and berries (wild fruits), consumable fish, crayfish, molluscs, algae
	Ornamental resources	++	++	++	++	++	Marginal	ornamental species and landscape elements
Regulatory services	Pollination	+++	+++	+++	+	+	Yes	bees and other pollinator species
	Pest & disease regulation	+++	+++	+++	+++	+++	Yes	non target arthropods, invertebrate and vertebrate predators, fungal species
	Air quality regulation	++	+	+++		+++	Marginal	plants
	...	...	...	...	...	...	...	...

SPG overview table (EFSA Panel on Plant Protection Products and their Residues, 2010)

Key driver	Ecosystem Service	Specific protection goal	Ecological entity	Attribute	Scale		
					Magnitude	Spatial	Temporal
Microbes	Nutrient regulation						
Microbes	Pest & disease regulation						
Honey bees	Pollination						
Non target arthropods	Pollination						
...	Genetic resources						
...	Cultural values						
...	...						

How has this changed ERA?

- ✓ Facilitating the use of better extrapolation models and fate/effect integration
- ✓ Used to generate trigger values (e.g., bees)
- ➢ It has not changed which species are tested or what endpoints are measured
- ➢ Not making quantitative, mechanistic links between test endpoints and service delivery

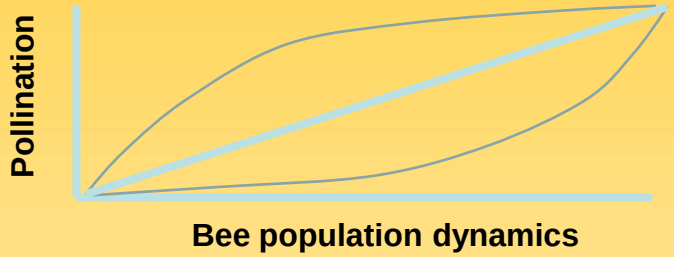


Several challenges

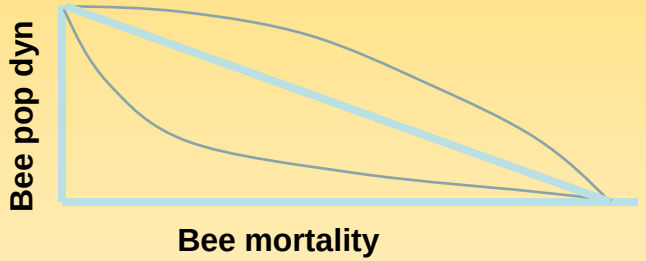
- ERA endpoints are moving further away from protection goals
- Effects on SPUs are not simple or robust proxies for impacts on service delivery
- Standardized conceptual models to link test endpoints to ES are lacking

How to make ES more than nice words?

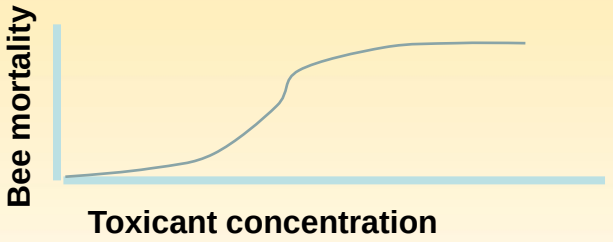
Step 3:
Ecological production function – Links SPU attribute to service delivery



Step 2:
Mechanistic effect model – Links toxicity test output to SPU attribute



Step 1:
Risk assessment data, e.g., toxicity tests



NIMBioS

National Institute for Mathematical and Biological Synthesis

Predictive Models for Ecological Risk Assessment

A NIMBioS Investigative Workshop

April 28-30, 2014

NIMBioS at the Univ. of Tennessee, Knoxville

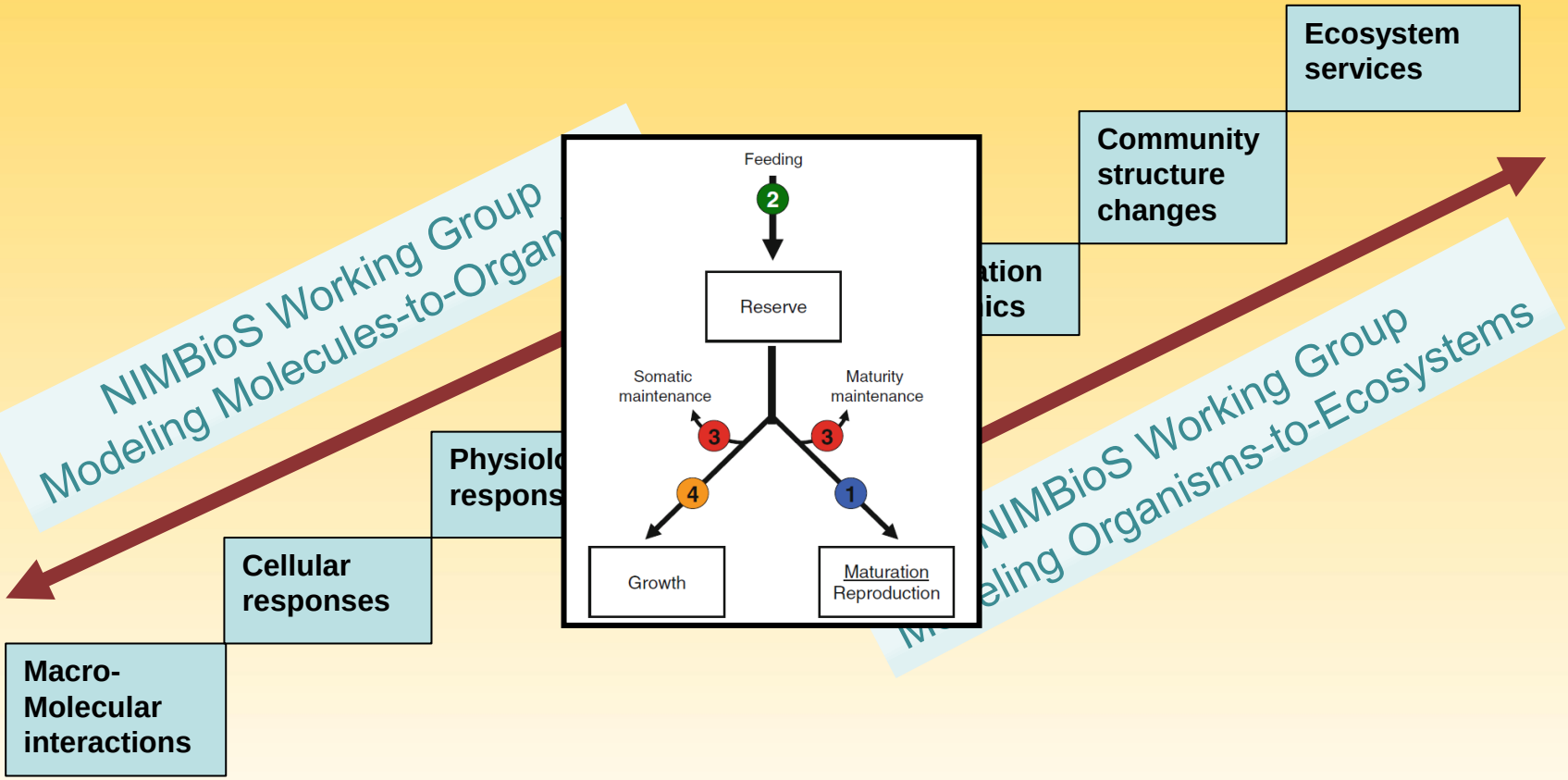
Organisms-to-Ecosystems WG

Mtg. 3 participants (L to R): Christopher Salice, Andrew Kanarek, Richard Rebarber, Yetta Jager, Roger Nisbet, Virginie Ducrot, Rob Pastorok, Valery Forbes, Bjorn Birnir, Pernille Thorbek, Randy Bruins, Nika Galic. (Kneeling): Kristina Garber, Steve Railsback.

Molecules-to-Organisms WG

Mtg. 2 participants (L to R): Natalia Garcia-Reyero, Chris Remien, Roger Nisbet, Andre Gergs, Angie Peace, Cheryl Murphy, Konstadia (Dina) Lika, Diane Nacci, Philipp Antczak, Irv Schultz, Teresa (Terry) Mathews, Karen Watanabe.

Goals of NIMBioS WGs

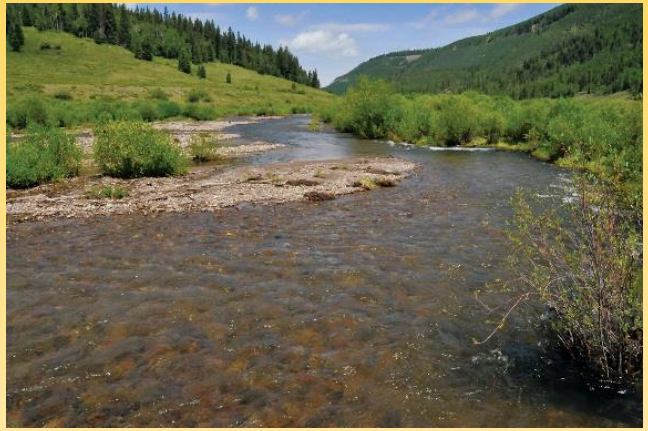


Overall Objectives of Orgs-ES WG

- Develop a general framework to mechanistically link ES to organismal toxicity endpoints
- Test framework using case study approach
- Identify key gaps in data and understanding
- Integrate with mols-to-orgs group
- Develop recommendations for research and implementation of framework

Case Study Approach:

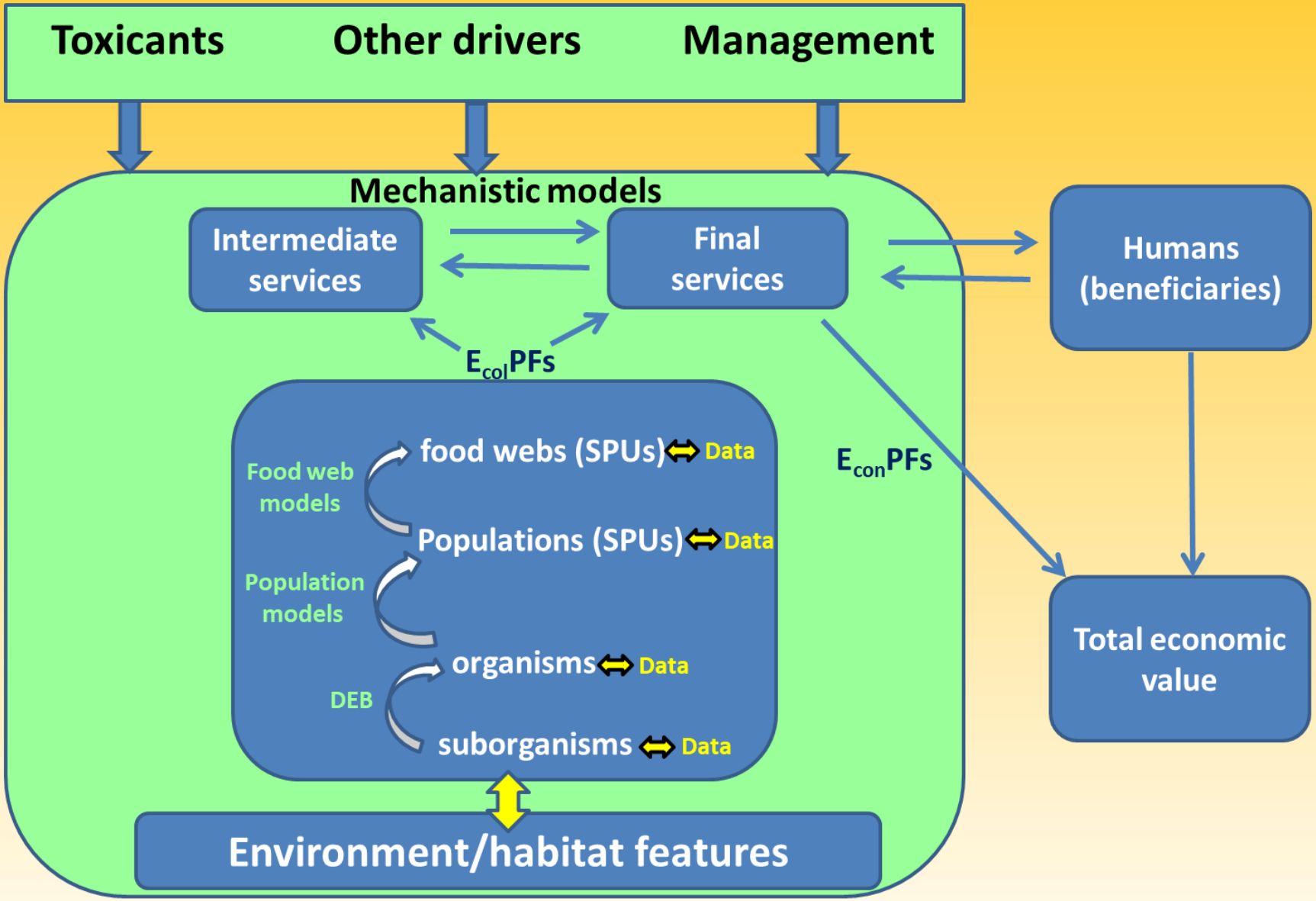
Mountain Stream



- ES: catchable fish; presence of fish
- Stressor: Ethynyl estradiol (EE2)
- Model: inSTREAM IBM

Midwest Reservoir

- ES: clear water; catchable fish
- Stressor: Insecticide
- Model: AQUATOX multi-species ecosystem model



General Conceptual Framework

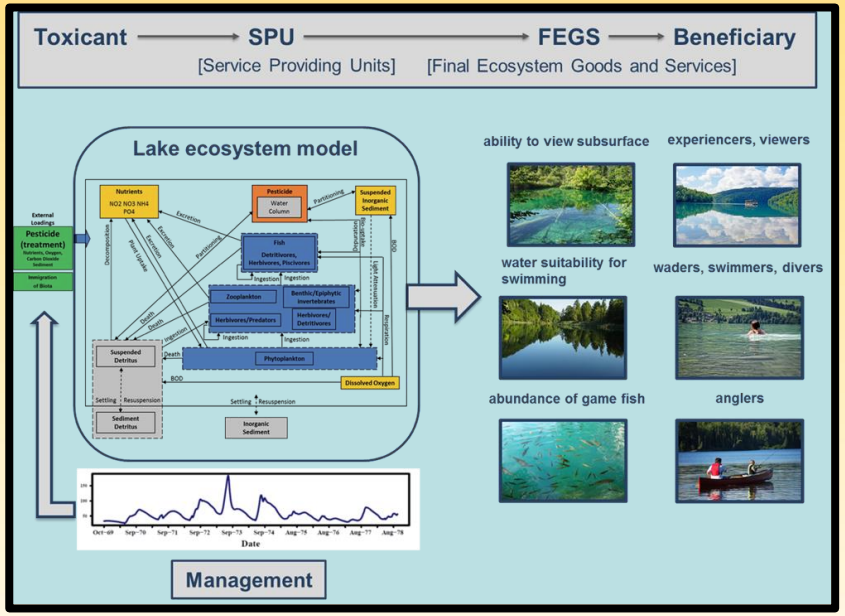
In This Issue:

ET&C FOCUS

Focus articles are part of a regular series intended to sharpen understanding of current and emerging topics of interest to the scientific community.

A Framework for Predicting Impacts on Ecosystem Services From (Sub)Organismal Responses to Chemicals

Valery E. Forbes,[a,*] Chris J. Salice,[b] Bjorn Birnir,[c] Randy J.F. Bruins,[d] Peter Calow,[e] Virginie Ducrot,[f] Nika Galic,[a] Kristina Garber,[g] Bret C. Harvey,[h] Henriette Jager,[i] Andrew Kanarek,[g] Robert Pastorok,[j] Steve F. Railsback,[k] Richard Rebarber,[l] and Pernille Thorbek[m]



Case Study 2: In Prep

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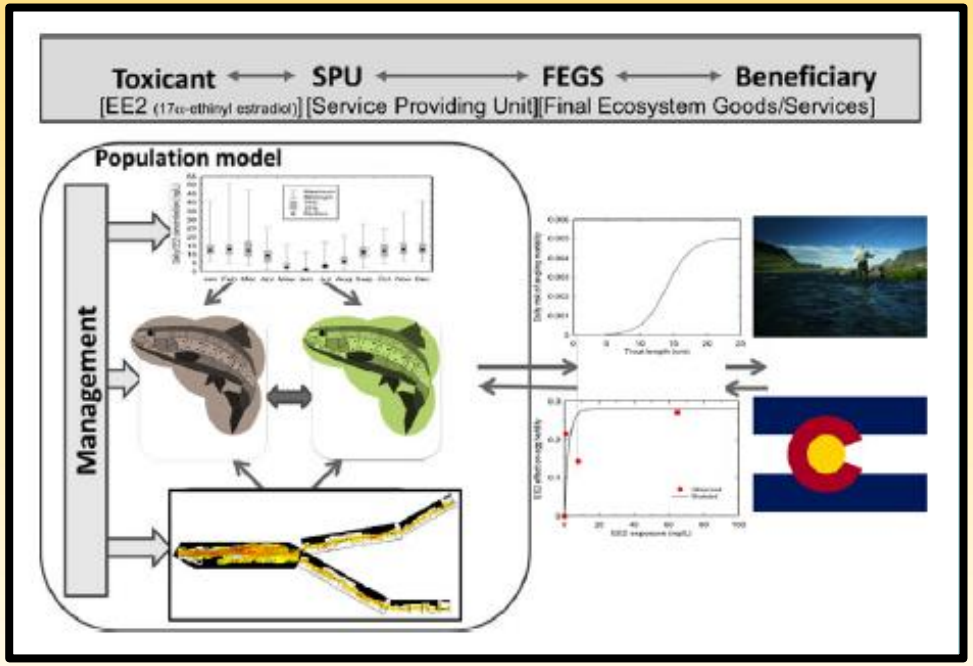
journal homepage: www.elsevier.com/locate/scitotenv

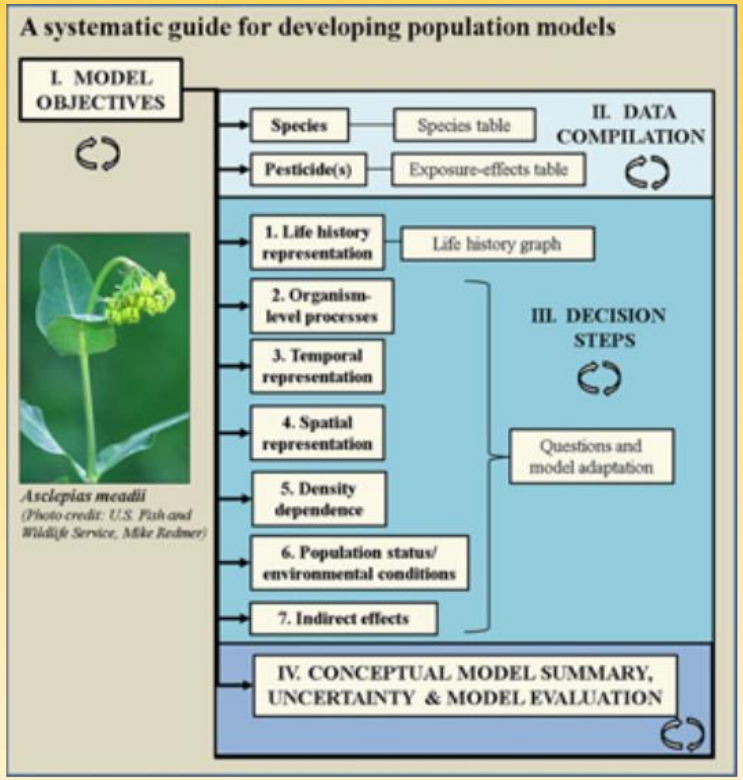
Predicting impacts of chemicals from organisms to ecosystem service delivery: A case study of endocrine disruptor effects on trout

Valery E. Forbes [a,*], Steve Railsback [b], Chiara Accolla [a], Bjorn Birnir [c], Randall J.F. Bruins [d,1], Virginie Ducrot [e], Nika Galic [f], Kristina Garber [g], Bret C. Harvey [h], Henriette I. Jager [i], Andrew Kanarek [g], Robert Pastorok [j], Richard Rebarber [k], Pernille Thorbek [l], Chris J. Salice [m]



Next Steps

- **Need a standard protocol for model design that links test endpoints to ES delivery**
- **Implement as a multi-stakeholder collaboration**
- **Improve efficiency, consistency and transparency in model development and implementation**



Schmolke et al 2017, STOTEN

Forbes, Schmolke, Accolla, Grimm. In preparation

Conclusions

- **For the ES framework to measurably improve ERA, it has to be more than a descriptive framework.**
- **We need more/better models to predict ES delivery from impacts on SPUs and impacts on SPUs from standard ERA information.**
- **We need more consistency and transparency in the models and less expert judgment.**