Implementing the ecosystem services approach in chemical risk assessments

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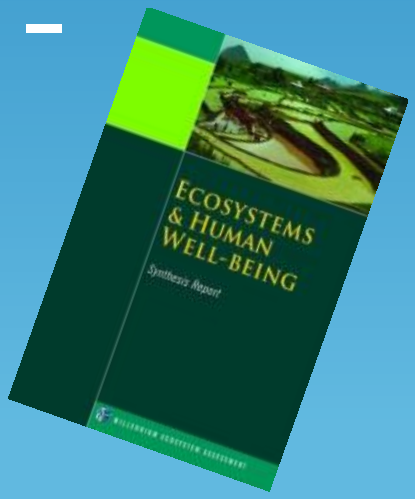
Setting the stage

- Framing protection goals in terms of Ecosystem Services is gaining momentum.
- One consequence of this is that we need models that can link impacts on organisms with delivery of services.
- There are substantial challenges – and not just for the science.



What are the advantages of using the ES concept?

- Strong communication tool
- Can be applied to all ecosystems (and all environmental compartments)
- Can be applied at different spatial and temporal scales
- Allows systematic and transparent assessment for making legislative protection goals operational

Everyone is talking about it, but is it being used in ERA?

In Europe, EFSA is leading the way

- European Food Safety Authority (EFSA)
  - Independent agency
  - Responsible for risk assessment of all aspects of food and feed safety
- Charged with updating Technical Guidance Documents for Pesticide Risk Assessment
- Guidance should help regulators decide:
  - What do we want to protect?
  - Where do we want to protect it?
  - Over what temporal and spatial scale do we want to protect it?

Recognizes that "we can't protect everything, everywhere, all the time!"

New Pesticide Regulation (EC) 1107/2009, Article 4.3 … the protection goals are pretty vague

(e) it shall have no unacceptable effects on the environment, having particular regard to the following considerations where the scientific methods accepted by the Authority to assess such effects are available:

- No effects?
- Small effects?
- Medium effects but including recovery?
- Large local effects ok as long as on larger scale no effects are detected?

(ii) its impact on non-target species, including on the ongoing behaviour of those species;

- Local scale? (In-crop)
- Wider spatial scale?
- Temporal scale?

Should recovery be considered?

(iii) its impact on biodiversity and the ecosystem.

- Structural biodiversity at species, subspecies or genetic diversity level? Functional biodiversity?

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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How EFSA is using the ES concept

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

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
	...	...	...	...	...	...	...	...

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

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						
...	...						

What impact will the EFSA approach have on ERA?

- It will not result in major differences in which species are tested.
- It will hopefully facilitate better extrapolation from what is tested to what we want to protect.
- But unlikely to make quantitative links with service delivery.
- Regulators seem reluctant to put value on ecosystem services or make tradeoffs explicit.

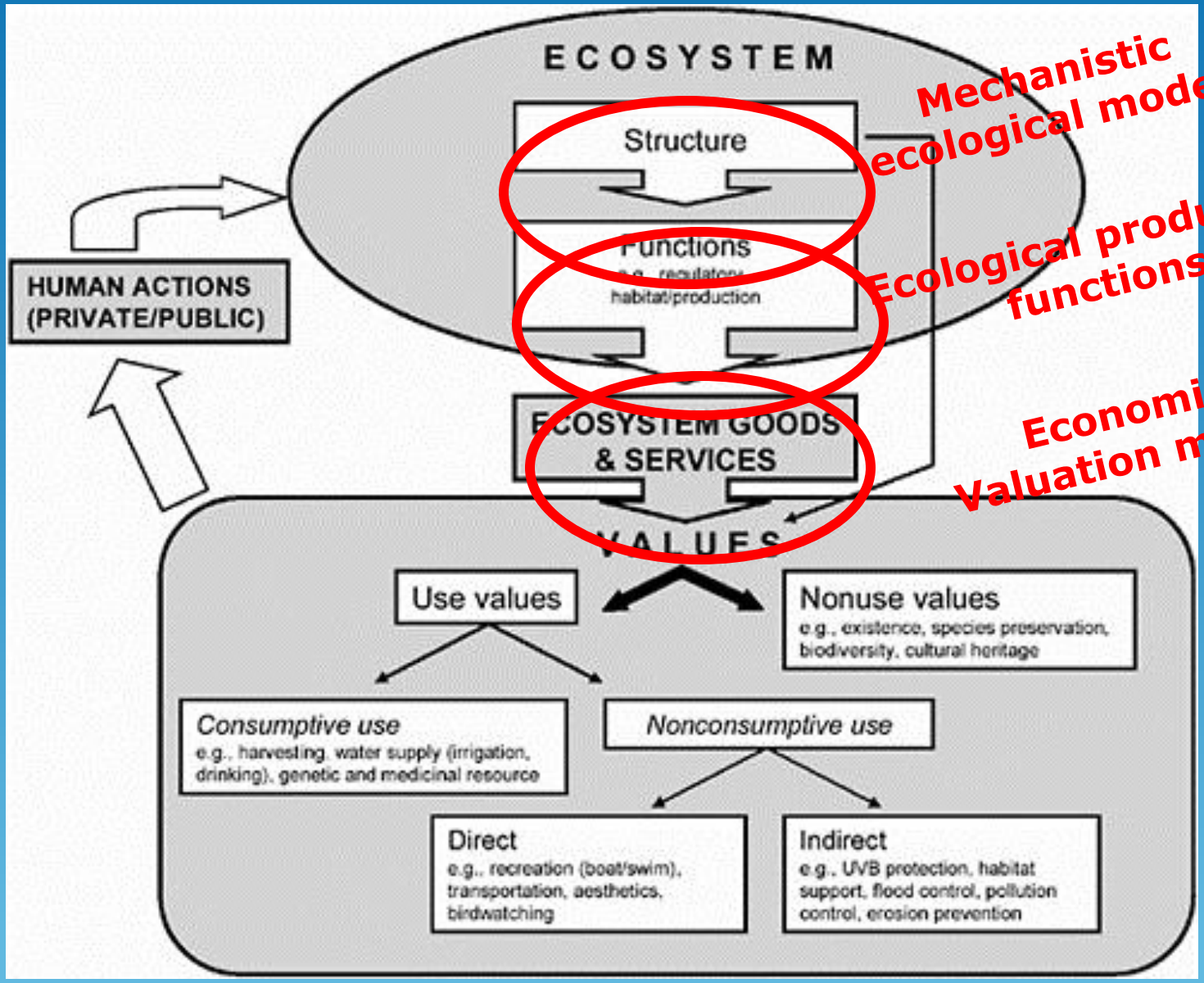
How the US EPA is using the ES concept

- ES = 18,100 hits on EPA's website (Feb 2012); 8,300 hits Dec 2013
- ES Research Program
  - Hard to tell if still active
  - Some site-specific case studies
  - ESRP for nitrogen
- Ecosystem-Based Management Tools Network http://ebmtoolsdatabase.org (large number of tools)
  - InVEST: Integrated Valuation of Ecosystem Services & Tradeoffs
  - ARIES: Artificial Intelligence for Ecosystem Services
  - MIME: Multi-scale Integrated Models of Ecosystem Services (no longer exists?)
- National Atlas of ES (first version in 2011?) – now EnviroAtlas; available in beta version

What impact will the US EPA approach have on ERA?

- There is less mention of ES than 2 yr ago
- The term seems to be mostly used in passing
- Seems that some initiatives have not followed through as planned
- Tools for ES assessment available, but unclear if/who is using them
- My interpretation is that EPA is backing away from using ES as a quantitative decision tool

Ideally, we need to do this.



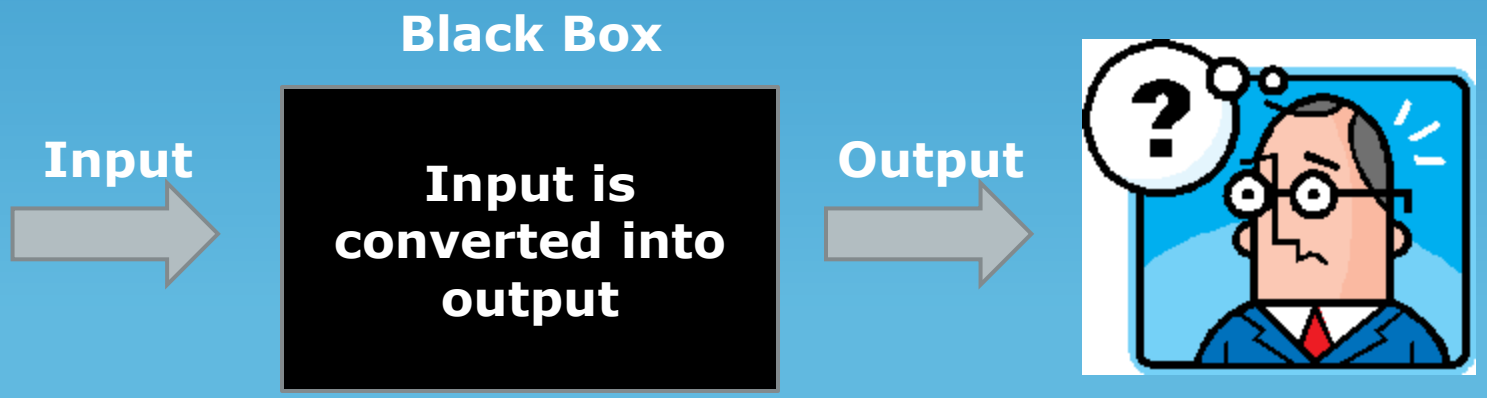
Source: National Academy of Sciences

Making real progress will require:

- New approaches for dealing with too much and too little data
- Computational approaches that are nonlinear, multidimensional, mechanistic & quantitative
- Translating model outputs into a form that can be used by decision makers
  - 'Value-relevant' outputs
  - Involvement of economists
  - Stakeholder dialogue

Challenge 1: Need User-Friendly Ecological Models

- Regulators won't use models they don't trust
- Most are not modelers themselves
- They are reluctant to make their decisions more complex and/or time consuming



Challenge 2: Need to link outputs of ecological models to ecosystem service delivery

- What properties of populations or groups of populations are tightly and robustly linked to services?

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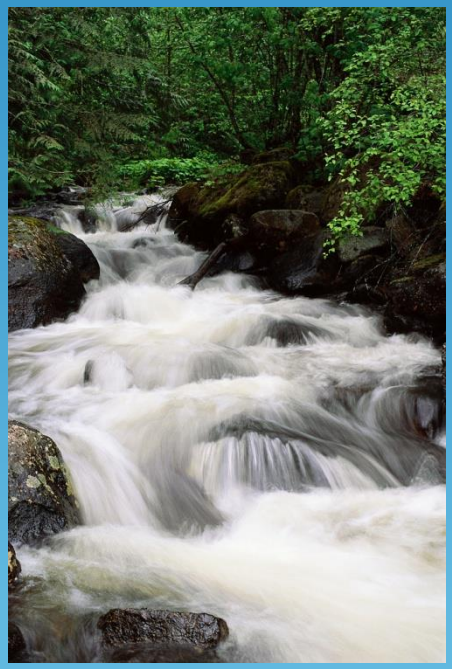
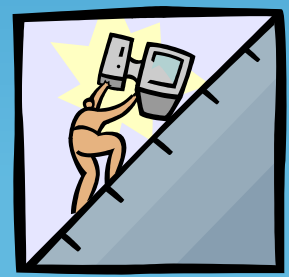
Challenge 3: Need to put values on ecosystem services

- Whose values?
- What units?
- Need to account for tradeoffs



Some progress is being made

- EFSA, (US EPA?) and other agencies supportive of Ecosystem Services as a framework
  - Should facilitate more/better science
- New legislation creating a need for value-relevant metrics that can be used in socioeconomic assessments (e.g., REACH)
- Research in this area is being supported
  - EU Framework Program (http://cream-itn.eu)
  - US EPA Ecosystems Research Program (http://www.epa.gov/research/ecoscience/)



But important questions remain

- How much complexity is necessary to include in models to make sensible management decisions?
- What properties of ecological systems are the most robust predictors of long-term service delivery?
- Can all ecosystem services be adequately valued so that tradeoffs can be appropriately quantified?

How do we get there?

- Create a new paradigm for linking responses of biological systems at different levels of organization that is mechanistic, quantitative and predictive.
- Establish strong multidisciplinary collaborations among ecologists, computer scientists, social scientists, and possibly others.
- Develop better understanding of how much (and which) complexities need to be included in models in order to make robust management decisions.
- Get buy-in from environmental decision makers & other stakeholders.
- Generate appropriate models and guidance that can be used by decision makers and as educational tools.