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# Ecosystem services-based environmental risk assessment for regulated stressors: learnings from case studies on pesticides in agricultural systems

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# Outline

- Why consider Ecosystem Services in a risk assessment for pesticides in agriculture?
- 2 case studies: what did we learn?
- The challenges: how can they be addressed?

# Why consider Ecosystem Services in a risk assessment for pesticides in agriculture?

# Environmental risk assessment for pesticides in agriculture

- Evaluate the potential risks to:
  - Groundwater quality
  - Surface water quality
  - Aquatic organisms (vertebrates and invertebrates, flora)
  - Terrestrial organisms in the fields (birds, mammals, soil micro- and macro-organisms, pollinators and other non-target arthropods)
  - Terrestrial organisms outside the field (all of the above, non-target plants)

- Protection goals:
  - *Its impact on non target species, including the ongoing behavior of those species;*
  - *Its impact on biodiversity and the ecosystem*

# Example: risk assessment to soil macro-organisms

**Nematicide applied to soil at pre-planting (tomatoes)**

| Species | Test item | endpoint | Tox/Exposure ratio | Trigger value |
|---|---|---|---|---|
| *Eisenia fetida* | Technical a.s. | 56-d NOEC = 770 mg/kg dry soil (from a 1 week aged study) | 19.57 | *5* |
| *Folsomia candida* | Technical a.s. | Mortality NOEC =11.6 mg 1,3-D/kg soil<br>Reproduction NOEC = 6.8 mg 1,3-D/kg soil | - | |
| *Folsomia candida* | Formulated (97.8% a.s.) | Mortality NOEC = 19.7 mg 1,3-D/kg soil<br>Reproduction NOEC = 6.7 mg 1,3-D/kg soil | **0.170** | *5* |

What does this mean?

- Possible risks, need risk assessment refinement in realistic worst case field study

# Example: risk assessment to soil macro-organisms

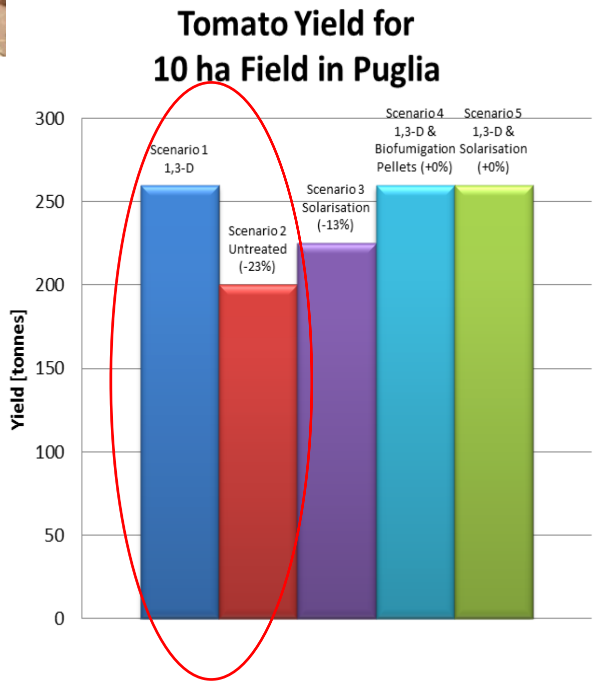
Field studies, not in tomato production fields but in crops where soil meso and macrofauna is more abundant

| Location | Crop | Application rate | Summary of findings |
|---|---|---|---|
| UK | Sugar beet | 224 L/ha | No difference in collembola abundance 2 years after application |
| N. Italy | Alfalfa/ winter wheat | 190 L/ha | No statistically significant differences to control were found in Collembola species along the year. |
| S. France | Fallow/ grasses | 200 L/ha | **Development of collembolan taxa was slightly delayed after treatment, but full recovery occurred 4 months after treatment.** |

What does this mean for collembolla populations?
Is this relevant for this crop only or other crops (e.g. tomato production)?
What is the likelihood of these effects to occur?
Can this be mitigated?
Can we just not treat the crop? What would be the consequences?

# What are we trying to achieve in the crop?





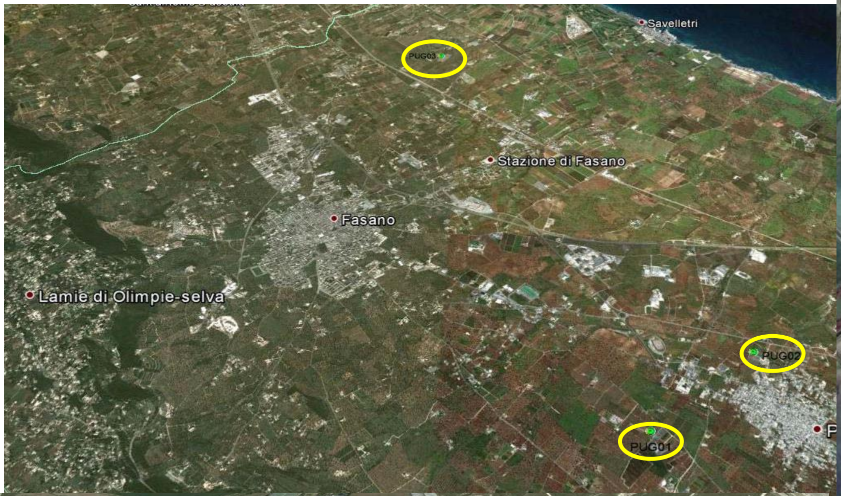

- ➢ 23% reduction yield vs transient effect on collembolla

What do we do?

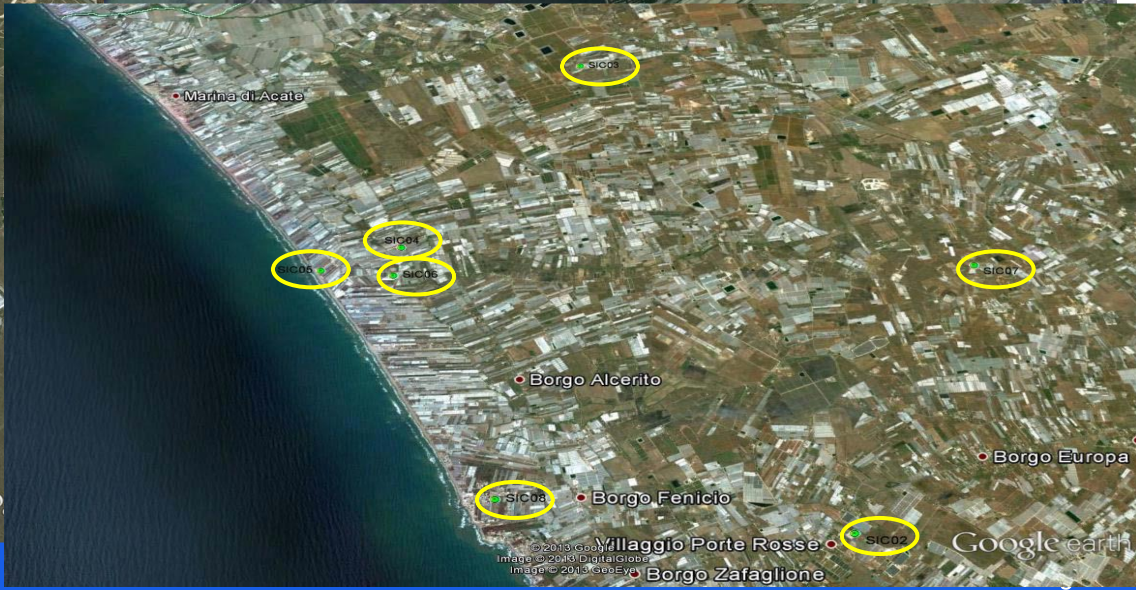
Option A: vote now!
Option B: go for a better informed decision making, looking at the services produced in these ecosystems, and how they will react to different agricultural scenarios, so that to take into account more parameters and their economical and sociological consequences

# Case study 1: interpret the risk assessment for a nematicide for use in tomato production in Italy

# Tomato production in Puglia and Sicily





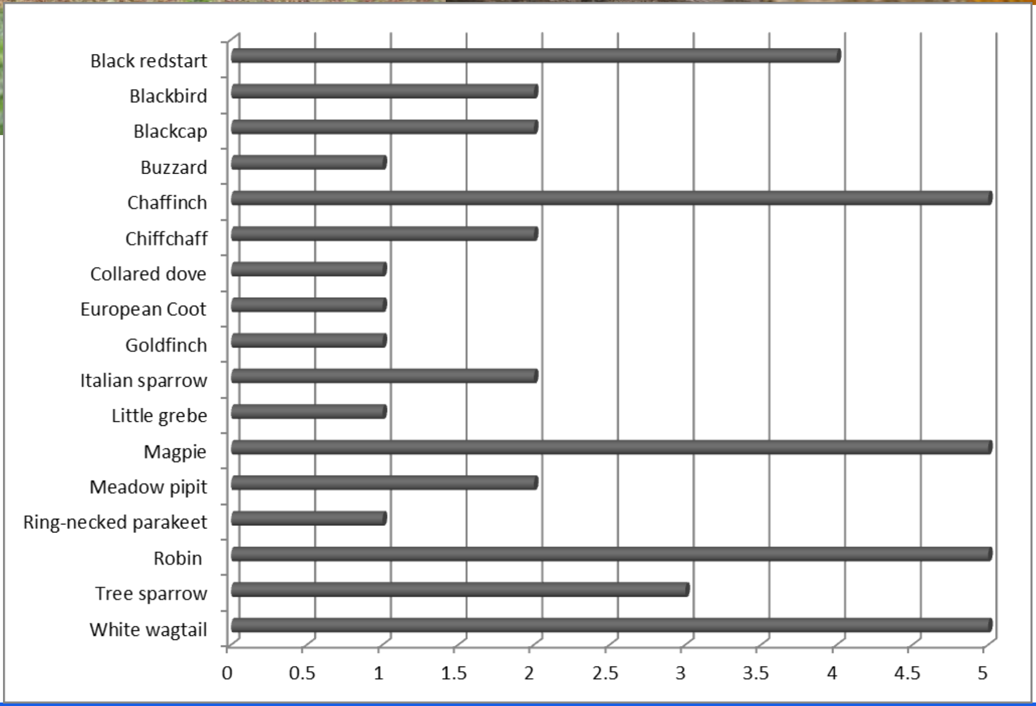
# Farm visits – data collection and ES listing

- Understand agricultural practices and their potential flexibility
- Description of environmental descriptors, assess their vulnerability
- Understand their variability

- Importance of the crop in space and time
- Sociological importance
- Financial aspects (not only the crop but the crop in the farm, and in the region)

- Cross verification of data with available national database

# Farm visits – data collection and ES listing



# Ecosystem services retained

Provisioning Services

- Food (crop)
- Freshwater (drinking water)

Habitat Services

- Functioning of ecological components of agro-ecosystem
- Link to EFSA key drivers (range of ecological niches)

Regulating Services

- Air quality regulation
- Moderation of extreme events
- Regulation of water flow
- Erosion prevention
- Pollination

Cultural Services

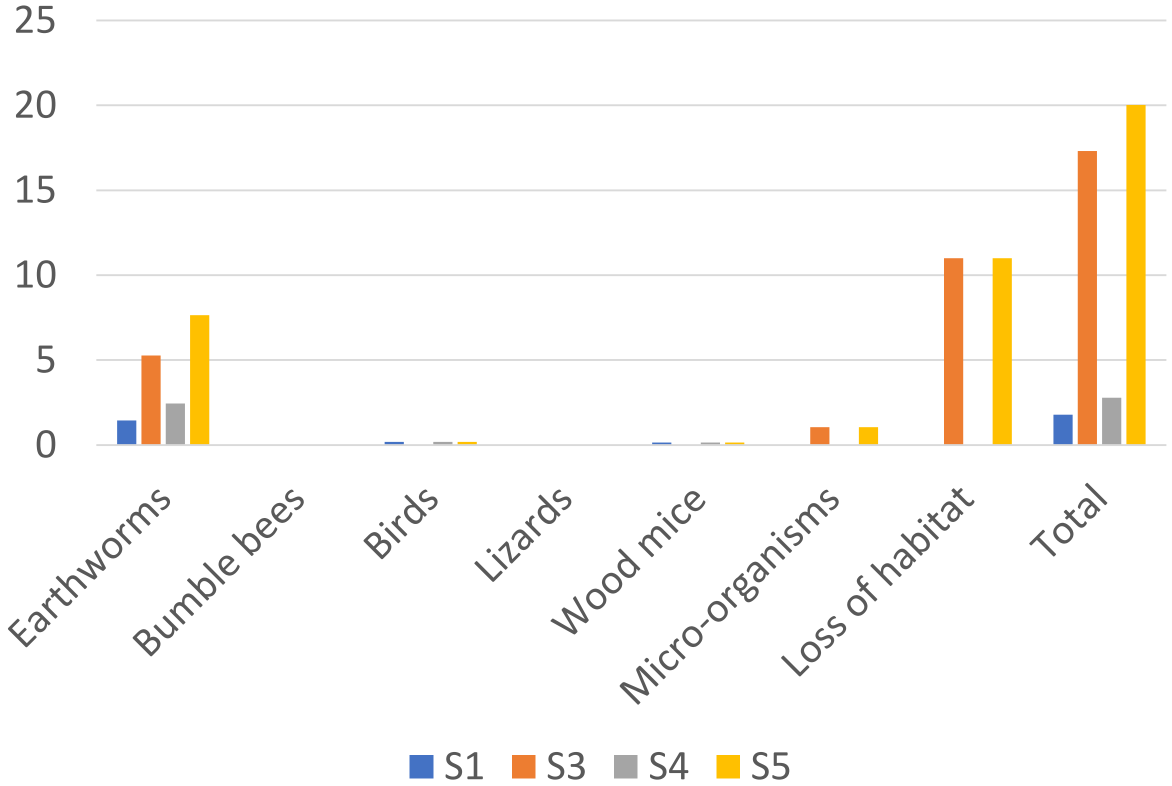
- Aesthetics and opportunities for recreation
- Inspiration for culture

# Habitat services - indicators

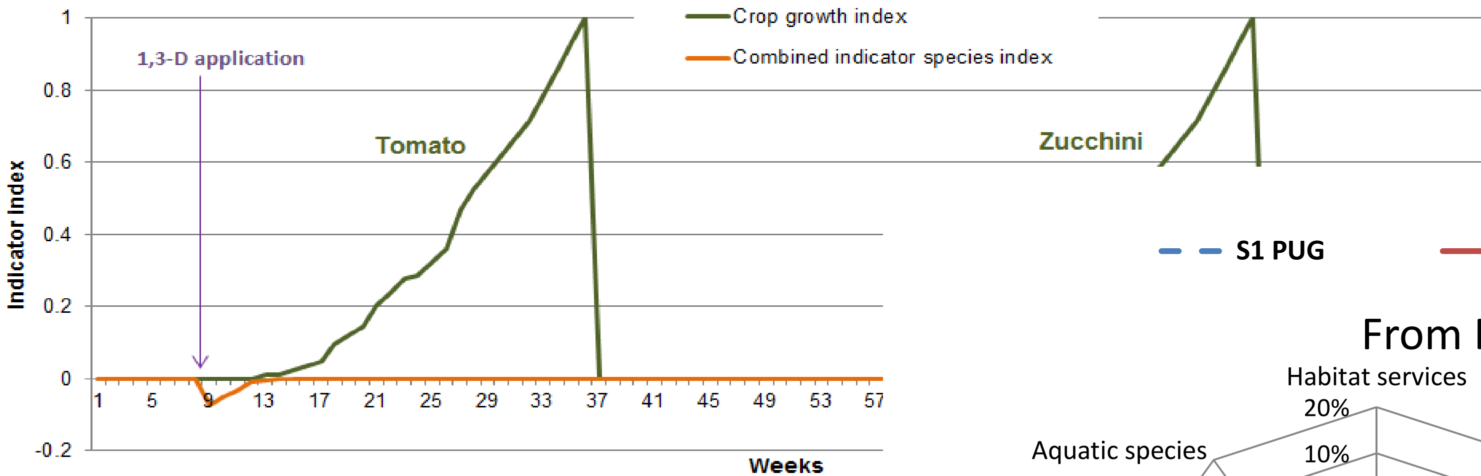
# Habitat services – combined risk indices

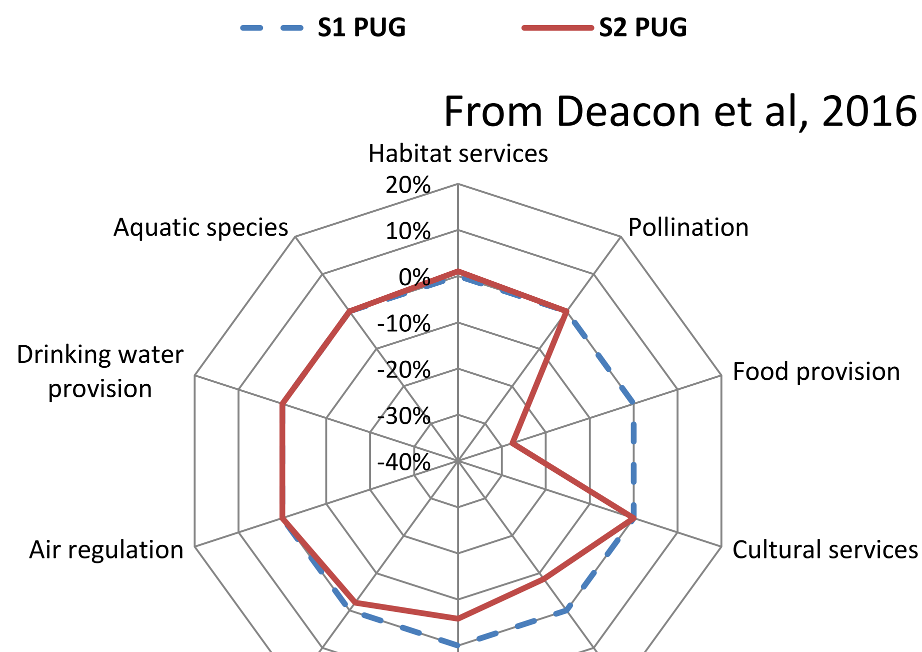
- Characterise exposure over the whole duration of the analysis (2 years)
- Use endpoints to calculate risk index for each indicator (risk index = exposure/toxicity endpoint)
- Combine risk indices

S1: nematicide control
S2: no control
S3: solarisation
S4: IPM nematicide and fumigation
S5: IPM nematicide and solarisation



# ES analysis – treatment vs no treatment




From Deacon et al, 2016

Study confirms that effects on soil organisms expected to be limited:

- Amplitude limited
- Abundance of collembolla was limited

Effects on habitat services < effects on other services e.g. food provision and soil erosion prevention

Next steps:

- Look at risk mitigation measures
- Reduce frequency of treatment in IPM programmes so that to “drive to zero”

# Learning from case study 1

- Field visits:
  - Provide visuals of what we are trying to do and of what we are trying to protect
  - Identifies indicators and how they rank compared to each other in terms of exposure/vulnerability

- ES analysis:
  - Informs on ES not taken into account in the risk assessment (soil erosion as such)
  - Informs on the role of agricultural practices in ecosystem provision function and how they compare to usual risk assessment
  - Can help interpret the risk assessment "in situ"
  - Can help reformulate the question "yields vs collembolla" and thus decision making

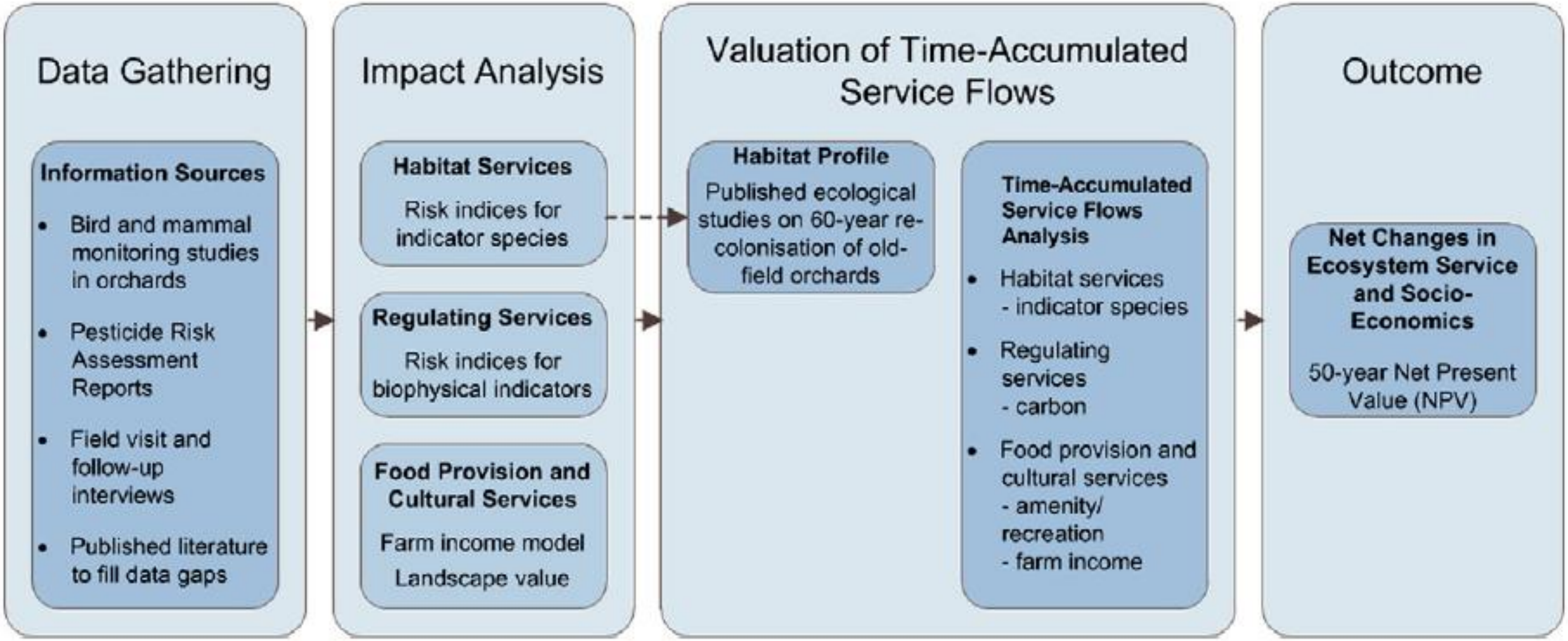
# Case study 2: interpret the risk assessment for an insecticide in citrus production in Spain

# Context

- Insecticide, used in oranges to control the Californian red scale
- Risk assessment indicates possible risks to birds, pollinators and non target arthropods
- Risk assessment refined by undertaking field studies and monitoring in citrus groves in the Valencia region, which showed that risks could be mitigated provided practice change
- ES study performed that compared 4 scenarios:
  - Insecticide is used
  - No treatment is used
  - Risk mitigation measures are implemented
  - Citrus production (30%) is abandoned due to economic pressure

# Approach and data collection

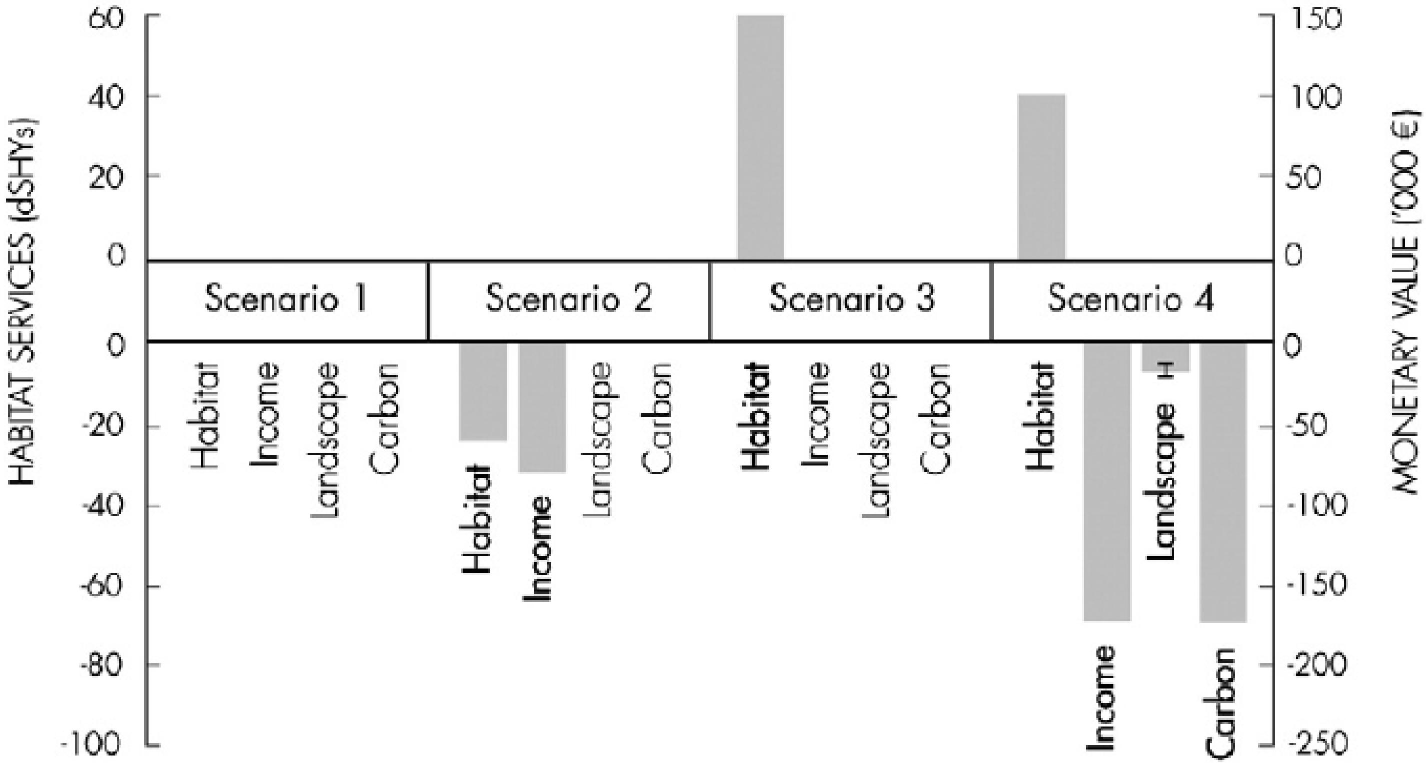
- Similar approach as before: identification of priority services produced in these production systems




From Deacon et al, 2015

# ES analysis

From Deacon et al, 2015




**Scenario 1:** current practice including chlorpyrifos

**Scenario 2:** hypothetical registration for chlorpyrifos cancelled

**Scenario 3:** illustrative with chlorpyrifos and conservation patches

**Scenario 4:** hypothetical, longer term with 30% loss of orchards

# Learning from case study 2

- Field visits: as for previous study
- ES analysis (to be added to previous learning):
  - Informs on ES other provided by land management and agriculture: irrigation that comes with the cultivation favours habitats and carbon sequestration (lower carbon storage potential in scrubs and grasslands than in citrus trees)
  - The gain in terms of habitat services by the creation of conservation areas can more than outweigh the losses due to the treatment (5 to 10 metres could suffice if well designed)

# Challenges of Ecosystem Services-based risk assessment: how can they be addressed?

# Challenges

Described in Maltby et al. (2018):

Table 1: Advantages and challenges of applying and ES framework to prospective and retrospective ERA identified by workshop participants from business (B), government (G) and academia (A).
RA = risk assessment; RM = risk management.

| Advantages | Challenges |
|---|---|
| Relevance: Focus RA on what people want when defining protection goals (B, G, A) | Anthropocentric (B, G, A) |
| Transparency: prioritization and trade-offs made explicit (B, G, A) | Valuation – how to do it (B) |
| Integration: Integration-across multiple stressors, habitats, scales and policies (B, G, A) | Complexity: data hungry, spatio-temporal variation (B, G, A) |
| Communication: More effective communication (B, G, A) | Unfamiliar language (G) |
| Informed RM decisions. Increases ecological realism, considers implications of different management in multifunctional landscapes, Enables cost/benefit of remedial actions (B, G) | Cost – need time and money (B, A) |
| Combines ES with intelligent testing (B) | Tools: Converting conventional ecotoxicity testing to ES / lack of ERA tools (B, G, A) |

# From data to ecosystem services

- The two case studies benefited of data-rich regulatory dossiers and field studies and visits
  - What do we do with “standard” regulatory package?
  - How to use data-rich case studies to build the tools we need?

- How do the current studies relate to Ecosystem Services?
  - How close are we with current studies?
  - Can modelling help? Recent study of Croft et al on pollination service (Croft et al, 2018)
  - ESs relate to multiple “endpoints”, including but not only environmental risk assessment endpoints” (e.g. soil erosion, carbon sequestration)

| Section | Division | Group | Class | Microbes | Algae | Plants | Nematods | Annelids | Rotifers | Echinoderms | Molluscs | Insects | Collembolans | Mites | Crustaceans | Mammals | Birds | Amphibians | Fish |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ecosystem services* | | | | *Taxonomic groups used in standard ecotoxicity tests* | | | | | | | | | | | | | | | |
| **Provisioning** | Nutrition | Biomass | Cultivated crops | | | black | | | | | | | | | | | | | |
| | | | Reared animals and their outputs | | | | | | | | grey | black | | | | grey | black | | |
| | | | Wild plants, algae and their outputs | grey | grey | black | | | | | | | | | | | | | |
| | | | Wild animals and their outputs | | | | | | | black | black | black | | | grey | grey | black | grey | black |
| | | | Plants and algae from in-situ aquaculture | | grey | grey | | | | | | | | | | | | | |
| | | | Animals from in-situ aquaculture | | | | | | | black | black | | | | grey | | | | black |
| | Materials | Biomass | Fibres and materials for use or processing | | grey | black | | | | grey | grey | grey | | | | grey | grey | | |
| | | | Materials for agricultural use | | grey | black | | | | | | | | | | grey | | | |
| | | | Genetic materials for industrial processes | grey | grey | grey | grey | grey | grey | grey | grey | grey | grey | grey | grey | grey | grey | grey | grey |
| | Energy | Biomass-based energy sources | Plant-based resources | | black | black | | | | | | | | | | | | | |
| | | | Animal-based resources | | | | | | | | | | | | | grey | grey | | |
| | | Mechanical energy | Animal-based energy | | | | | | | | | | | | | grey | | | |
| **Regulation & Maintenance** | Mediation of waste and toxics | Mediation by biota | Bioremediation | black | black | black | | grey | | | | | | | | | | | |
| | | | Filtration/sequestration/storage/accumulation | grey | grey | grey | grey | black | grey | grey | black | black | grey | grey | black | grey | grey | grey | black |
| | Mediation of flows | Mass flows | Mass stabilisation and erosion control | | grey | black | | | | | | | | | | | | | |
| | | Liquid flows | Hydrological cycle, water flow maintenance | | | grey | | grey | | | | | | | | | | | |
| | | | Flood protection | | grey | black | | | | | | | | | | | | | |
| | | Gaseous / air flows | Storm protection | | | grey | | | | | | | | | | | | | |
| | | | Ventilation and transpiration | | | grey | | | | | | | | | | | | | |
| | Maintenance of physical, chemical, biological conditions | Lifecycle maintenance, habitat and gene pool | Pollination and seed dispersal | | | | | | | | | grey | | | grey | grey | grey | | |
| | | | Maintaining nursery populations and habitats | | | grey | | | | | | | | | | | | | |
| | | Pest and disease control | Pest control | | | | grey | | | | | grey | | black | | grey | grey | grey | grey |
| | | | Disease control | | | | grey | grey | | | | | | grey | | | | | |
| | | Soil formation and composition | Weathering processes | grey | | | | grey | | | | | | | | | | | |
| | | | Decomposition and fixing processes | black | | | black | black | | | | black | black | grey | grey | | | | |
| | | Water conditions | Chemical condition of freshwaters | grey | grey | grey | | | | | | | | | | | | | |
| | | | Chemical condition of salt waters | grey | grey | | | | | | | | | | | | | | |
| | | Atmospheric composition and climate regulation | Global climate regulation by GHG reduction | | grey | grey | | | | | | | | | | | | | |
| | | | Micro and regional climate regulation | | | grey | | | | | | | | | | | | | |

Table 2: Mapping of standard ecotoxicity test guidelines against ES. Taxon × ES combinations where there are guidelines for relevant species and (potentially) relevant measurement endpoints are shaded black. Taxon × ES combinations where there are guidelines for relevant taxonomic groups are shaded grey.

From Maltby et al, 2018

# Valuation

- The value of ES is context-dependant (the price of tomatoes is, so collembolla's head price must be!)

- But we can walk towards the best outcome:
  - Involve stakeholders in the problem formulation: agree on the objectives, and the means to achieve the best results on all the ES that matter

- Agree on the significance of a change in value: 23% yield loss has got implications that need attention (revenue, soil erosion etc):
  - May help re-define metrix
  - Identify compensation

# CARES II project

- Proof of concept study, to evaluate the practical applicability of an ES approach to prospective and retrospective chemical risk assessment

- 3 case studies to address a different European regulation - 1107/2009, REACH, WFD, and compare the outcome of an ecosystem services-based risk assessment with the outcome of current regulatory risk assessment approaches

- Outcome: evaluation of the added value to regulatory decision making of adopting an ecosystem service approach to chemical risk assessment

# Conclusions

Ecosystem Services-based risk assessment can provide added value to the assessment of regulated chemicals:

- Discuss the outcome of risk assessment into context
- Identify best way forward: risk mitigation or change of practices

ES-based risk assessment helped identify key services and their relation to multiple (environmental and non environmental) indicators in their maintenance

Case studies can help to highlight interrelations and design future tools

# Thank you for your attention!


- Maltby L, Van den Brink PJ, Faber JH and Marshall S, 2018. Advantages and challenges associated with implementing an ecosystem services approach to ecological risk assessment for chemicals. Science of the Total Environment, 621: 1342-1351
- Deacon S, Alix A, Knowles S, Wheeler J., Tescari E, Alvarez L, Nicolette J, Rockel M, Burston P, and Quadri G, 2016. Integrating ecosystem services into crop protection and pest management: case study with the soil fumigant 1,3-dichloropropene and its use in tomato production in Italy. Integrated Environmental Assessment and Management, 12 (4): 801-810.
- Deacon S, Norman S, Nicolette J, Reub G, Greene G, Osborn R, and Andrews P, 2015. Integrating ecosystem services into risk management decisions: case study with Spanish citrus and the insecticide chlorpyrifos. Science of the Total Environment, 505: 732-739.



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