Introduction to protection goals, ecosystem services and roles of risk management and risk assessment.

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Robust and efficient environmental risk assessment procedures require clear protection goals specifying what to protect, where to protect it and over what time period.

Regulation (EC) No 1107/2009

*"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:*

*(i) its fate and distribution in the environment, particularly contamination of surface waters, including estuarine and coastal waters, groundwater, air and soil taking into account **locations distant from its use** following long-range environmental transportation;*

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

*(iii) its impact on **biodiversity** and the **ecosystem**."*

(Article 4.3)

Convention on Biological Diversity

"the variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems"

Soil

- Thematic Strategy for Soil Protection, Soil Framework Directive
- Protection and sustainable use of soil.
- Functions - environmental, economic, social, cultural
  - biomass production, including in agriculture and forestry;
  - storing, filtering and transforming nutrients, substances and water;
  - biodiversity pool, such as habitats, species and genes;
  - physical and cultural environment for humans and human activities;
  - source of raw materials;
  - acting as carbon pool;
  - archive of geological and archaeological heritage.

Water

- Water Framework Directive 2000/60/EC
  - “good ecological status”, “good chemical status”
  - Assumptions: ecosystem sensitivity depends on the most sensitive species, and protecting ecosystem structure protects ecosystem function.
- Marine Strategy Framework Directive 2008/56/EC
  - No significant impacts on or risks to marine biodiversity, marine ecosystems, human health or legitimate uses of the sea.

General protection goals

- Biodiversity, ecological functions and use of ecosystems.
- All terrestrial and aquatic ecosystems, irrespective of location
- ‘Everything, everywhere’
- No qualification of “unacceptable effects”, “risk”, “significant impacts” etc.

- Trade-offs between agricultural production and biodiversity.
- Not all biodiversity can be protected in every location all the time

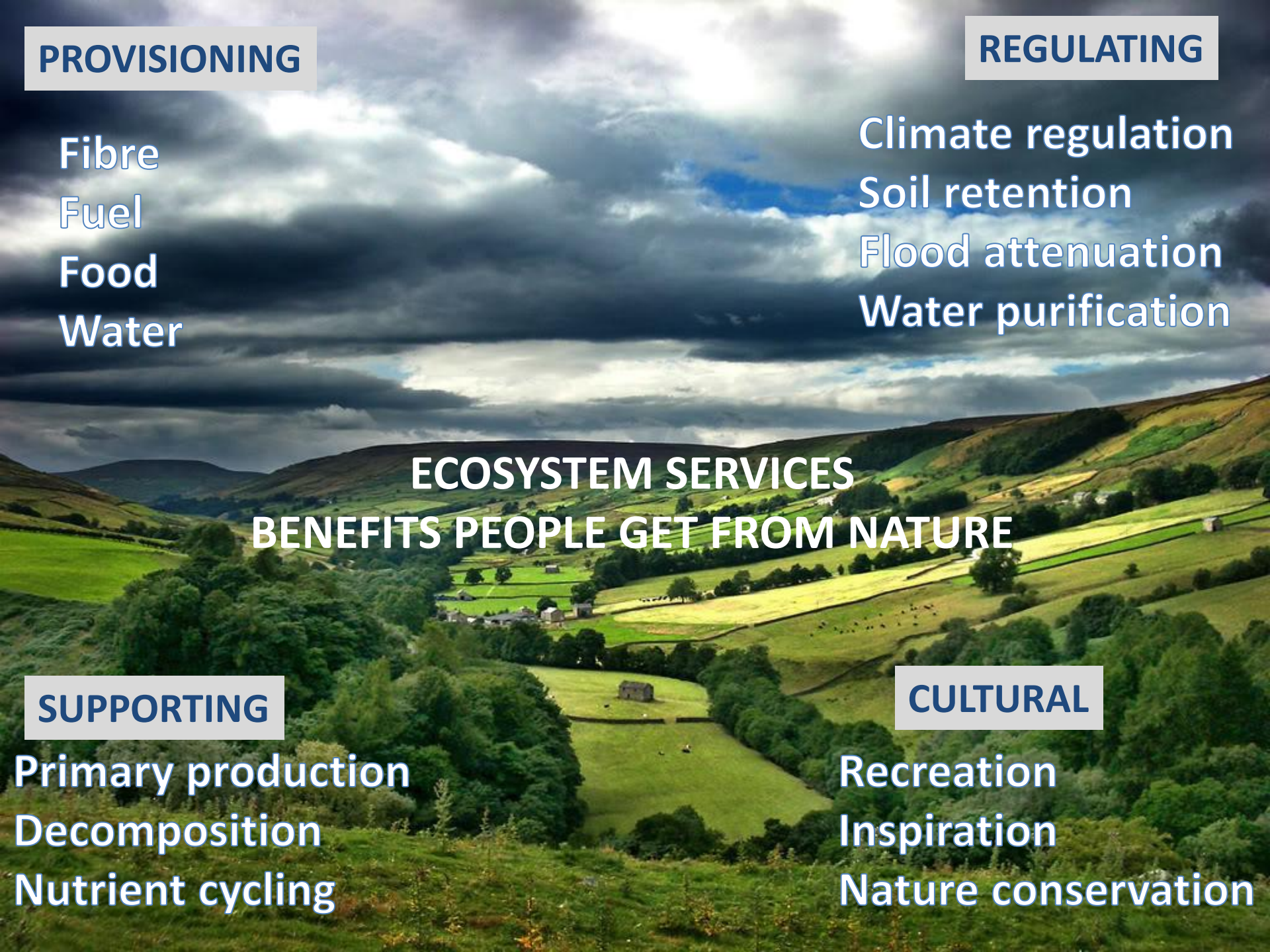
European Food Safety Authority

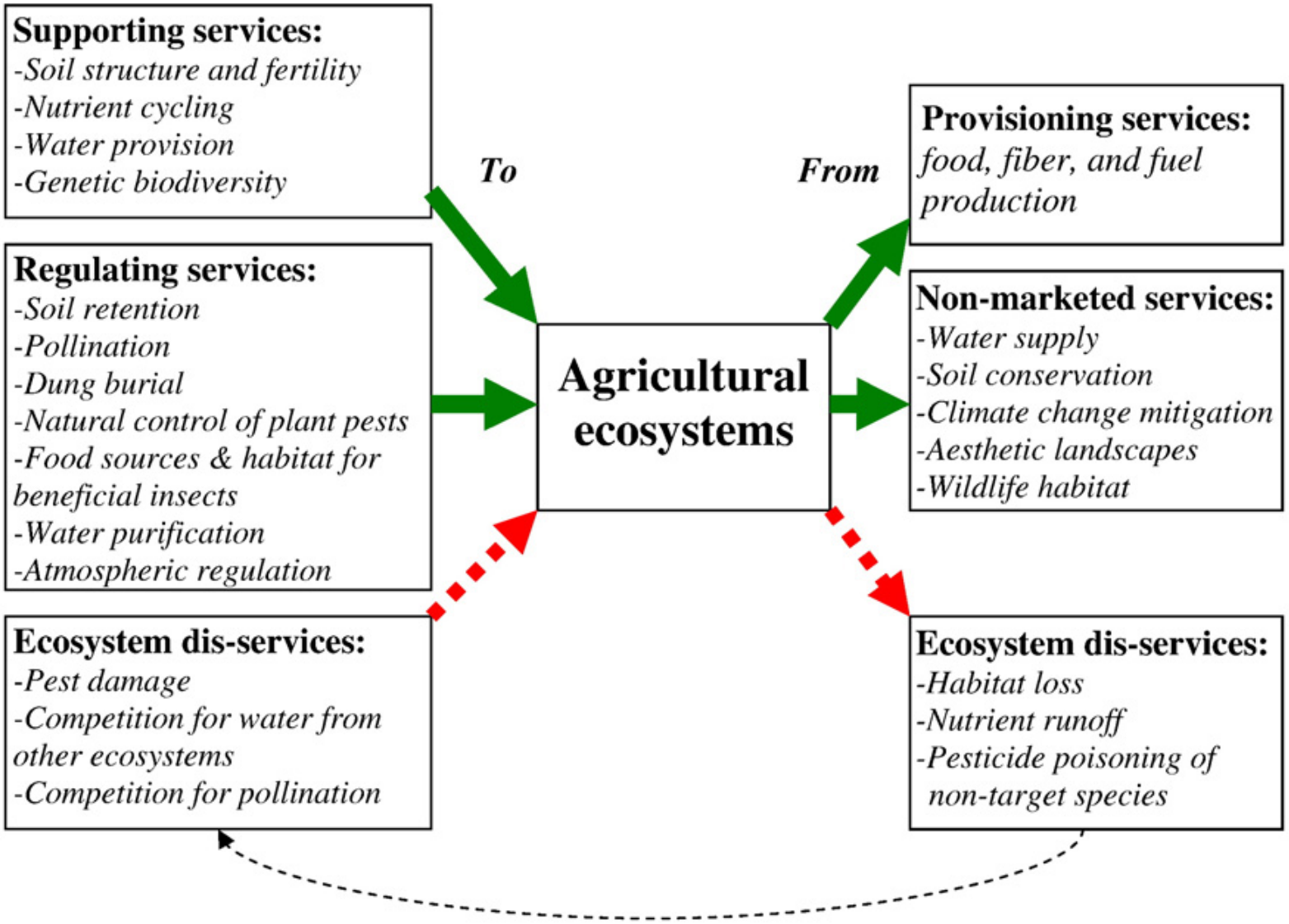
EFSA Journal 2010;8(10):1821

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]

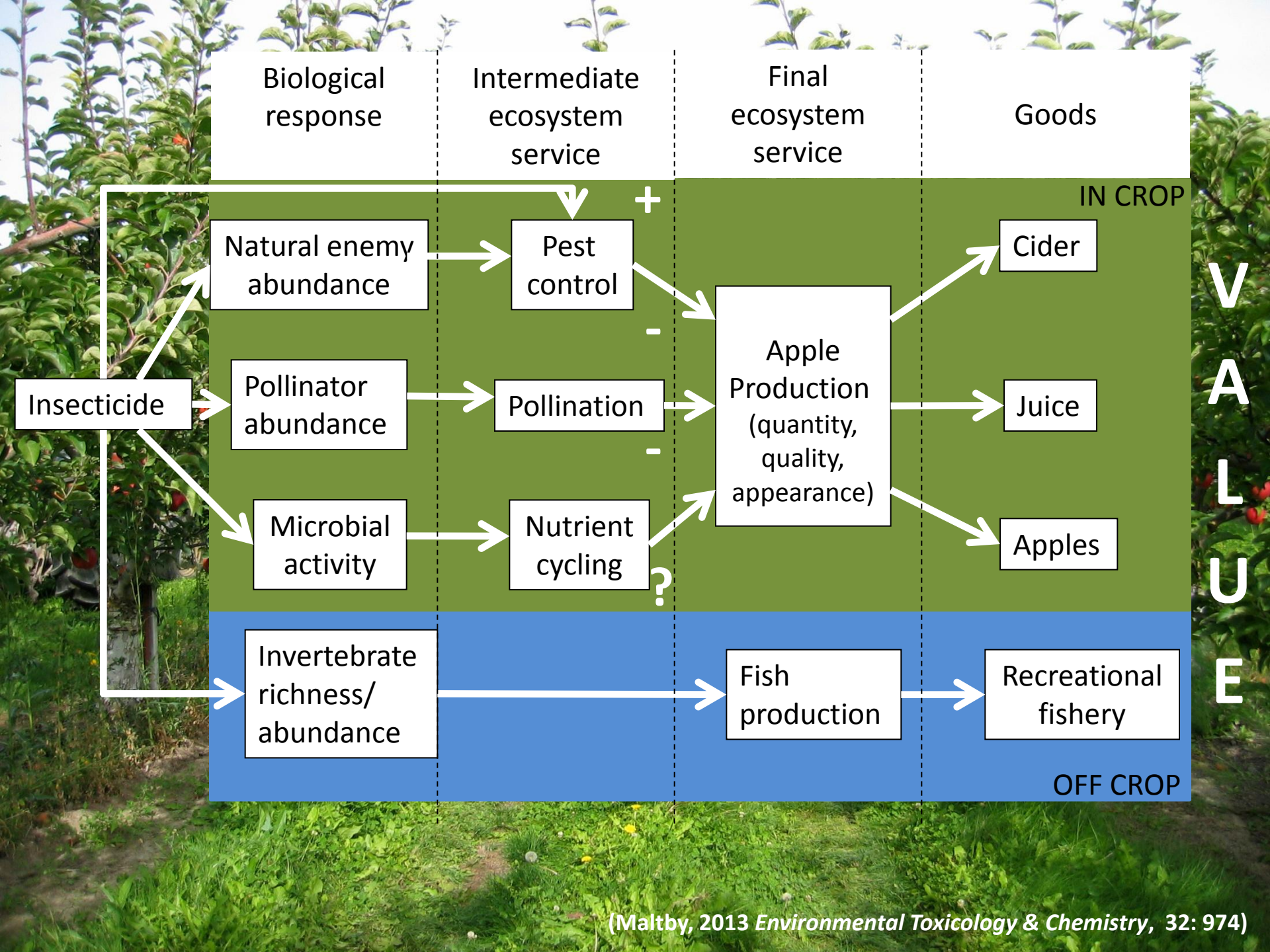
*"the **entities** that need to be protected, the **attributes and/or functions** of those entities, as well as the **magnitude, temporal and spatial scales of effects** on these attributes and/or functions that can be tolerated without impacting the general protection goal and the required degree of certainty with which the protection goal defined should be achieved."*


PROVISIONING
Fibre
Fuel
Food
Water
REGULATING
Climate regulation
Soil retention
Flood attenuation
Water purification
ECOSYSTEM SERVICES
BENEFITS PEOPLE GET FROM NATURE
SUPPORTING
Primary production
Decomposition
Nutrient cycling
CULTURAL
Recreation
Inspiration
Nature conservation



Feedback effect of dis-services from agriculture to agricultural input (e.g., removal of natural enemy habitat can encourage pest outbreaks)

(Zhang et al. 2007, *Ecological Economics,* 64: 253)



(Maltby, 2013 *Environmental Toxicology & Chemistry*, 32: 974)

Expert opinion on the importance to the EU of MA ecosystem services and the role of biodiversity in maintaining them.

Category	Type	EU rating	Increasing role of biodiversity
Supporting	Soil formation	High	Low
	Nutrient cycling	High	High
	Primary production	High	High
	Water cycling	High	Low
Regulating	Climate regulation	High	Low
	Disease regulation	Unknown	High
	Water	High	Low
	Pollination	Medium	High
Provisioning	Food	High	Low
	Freshwater	High	Low
	Fuel	Medium	Low
	Fibre	Medium	Low
	Biochemicals	Low	High
	Genetic resources	Low	High
	Environmental quality	High	Low
Cultural	Spiritual/religious/aesthetic/inspirational/sense of place	High	Low
	Recreation/ecotourism/cultural/heritage/educational	High	High

(EASAC 2009 *Ecosystem Services and Biodiversity in Europe*)

Table 1 | Balance of evidence linking biodiversity to ecosystem services

(Cardinale et al 2012, *Nature*, 486, 59-67)

Category of service	Measure of service provision	SPU	Diversity level	Source	Study type	*N*	Relationship	
							Predicted	Actual
Provisioning								
Crops	Crop yield	Plants	Genetic	DS	Exp	575	↗	↗
			Species	DS	Exp	100	↘	↕
Fisheries	Stability of fisheries yield	Fish	Species	PS	Obs	8	↗	↗
Wood	Wood production	Plants	Species	DS	Exp	53	↗	↗
Fodder	Fodder yield	Plants	Species	DS	Exp	271	↗	↗
Regulating								
Biocontrol	Control of herbivorous pests (bottom-up effect of plant diversity)	Plants	Species	DS*	Obs	40	↗	↗
		Plants	Species	DS†	Exp	100	↗	↗
		Plants	Species	DS‡	Exp	287	↘	↕
		Plants	Species	DS§	Exp	100	↘	0
	Control of herbivorous pests (top-down effect of natural enemy diversity)	Natural enemies	Species/trait	DS*	Obs	18	↗	↗
		Natural enemies	Species	DS†	Exp/Obs	266	↗	↗
		Natural enemies	Species	DS‡	Exp	38	↘	↕
	Resistance to plant invasion	Plants	Species	DS	Exp	120	↗	↗
	Disease prevalence (on plants)	Plants	Species	DS	Exp	107	↗	↗
	Disease prevalence (on animals)	Multiple	Species	DS	Exp/Obs	45	↘	↕
Climate	Primary production	Plants	Species	DS	Exp	7	↗	0
	Carbon sequestration	Plants	Species	DS	Exp	479	↗	↗
	Carbon storage	Plants	Species/trait	PS	Obs	33	↘	↕
Soil	Soil nutrient mineralization	Plants	Species	DS	Exp	103	↗	↗
	Soil organic matter	Plants	Species	DS	Exp	85	↗	↗
Water	Freshwater purification	Multiple	Genetic/species	PS	Exp	8	↗	0
Pollination	Pollination	Insects	Species	PS	Obs	7	↘	↕

Biodiversity and ecosystem services

- Biodiversity of what, measured how?
  - Taxonomic diversity v functional diversity
  - Genetic diversity, species diversity (local, regional), habitat diversity
  - All taxa or specific groups.
- Equating biodiversity with ecosystem services
  - Managing one will automatically enhance the other.
  - “Ecosystem services perspective”
- Biodiversity as an ecosystem service
  - Intrinsic value for biodiversity.
  - “conservation perspective”
- Biodiversity can be a:
  - regulator of intermediate services, final ecosystem service, good

(Mace et al 2012, *Trends in Ecology & Evolution*, 27, 19-26)

Assessing chemical risk within an ecosystem services framework

- What portfolio of services are required from a particular landscape and by whom?
- Which ecological components provide the services demanded and how are they related to service provision?
- What is the relationship between chemical exposure and key service provider attributes?
- What are the interactions (synergies, trade-offs) between ecosystem services?

(Maltby, 2013 *Environmental Toxicology & Chemistry*, 32: 974)

Approach

Ecosystem services affected

↓

Identify key drivers (SPU)
(i.e. taxa, functional groups)

↓

Specify dimensions
(Ecological entity & attribute, impact magnitude & scale)

Provisioning Service
FOOD PRODUCTION
Population abundance /biomass, internal concentration

Regulating Service
POLLINATION
Population abundance and foraging behaviour

Supporting Service
NUTRIENT CYCLING
Microbial function

Cultural Service
INSPIRATION/RECREATION
Individual behaviour and fitness

Comments

- Maintenance of a diverse range of ecosystem services in the landscape/watershed.
- Short-term effects at local scale only.
- Ecological entities to be protected are generally populations or higher.
- Protecting populations protects species.
- Approach enables a systematic and transparent assessment of all specific protection goal options.

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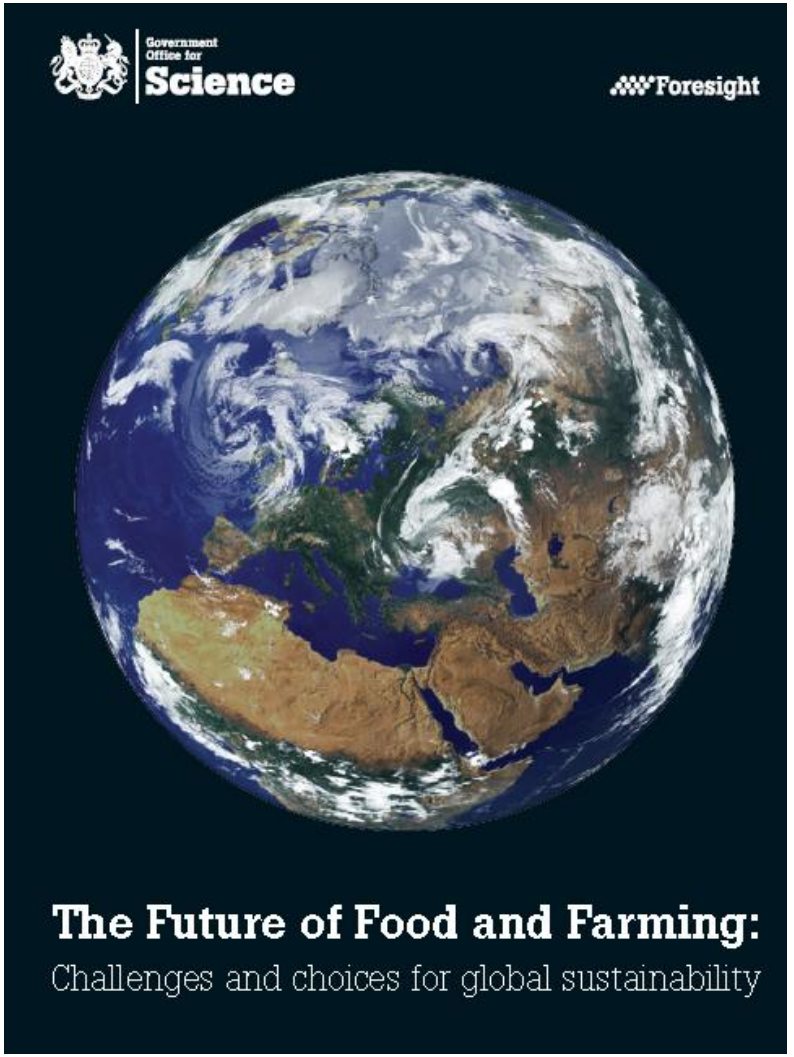
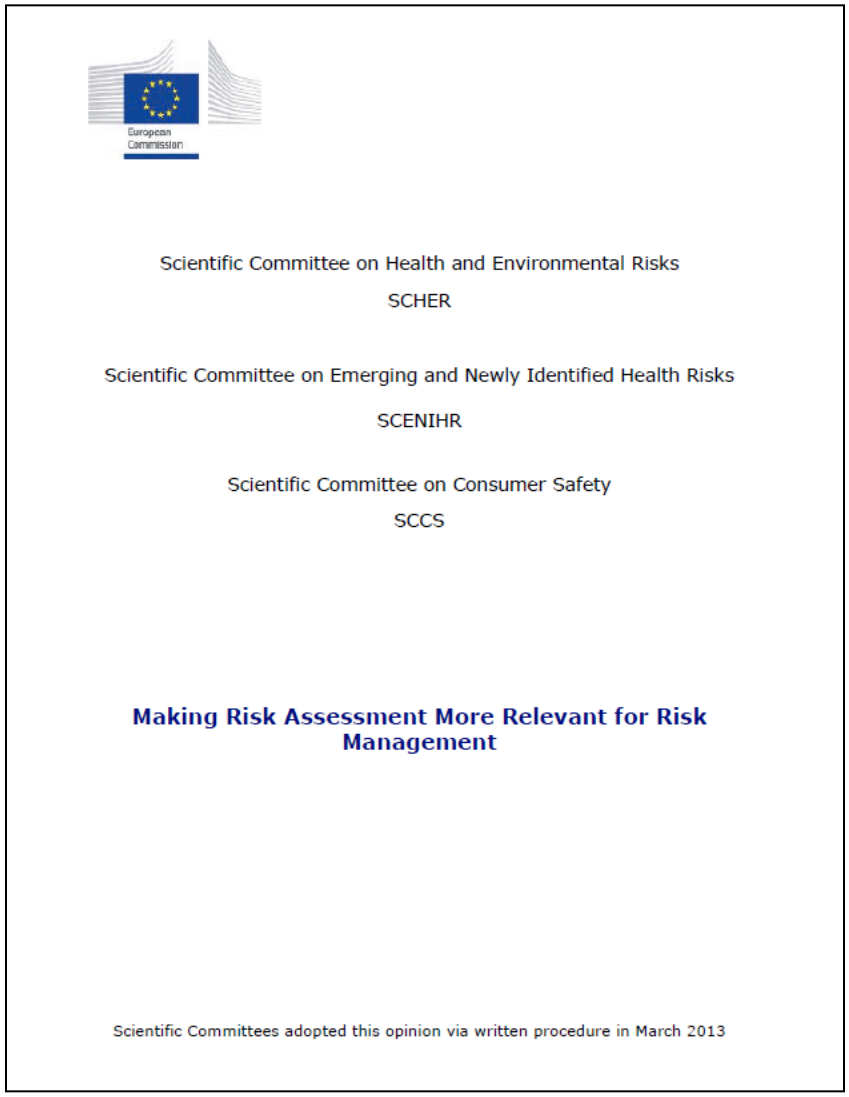
Multifunctional landscapes

- Integrate food production and other services (e.g. biodiversity).
- “a sustainable food system would: not erode the natural capital of the agro-ecosystem; limit the release of substances that may compromise ecosystem services from other habitats; prevent the further loss of biodiversity.”





"risk assessment should relate to the protection goals that are important for management. One aspect of this is making risk assessment relevant for socio-economic assessments. … this means using criteria such as changes in ecosystem services."

Summary

- Protections goals: what to protect, where and for how long.
- General protection goals: biodiversity
  - “everything, everywhere.”
  - No qualification of acceptable risk or effects.
- Inherent trade-off between agriculture and biodiversity
- Specific protection goals: ecosystems services
  - Makes trade-offs in multifunctional landscapes transparent
  - Provides a mechanism for protecting species diversity
  - Enables socio-economic assessments
  - Makes risk assessment more relevant for risk management