

ECOSYSTEM SERVICES

FROM POLICY TO PRACTICE

Indicators for ecosystem services provided by soils

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5th SETAC Europe
Special Science Symposium
15-16 February 2012, Hotel Marivaux, Brussels



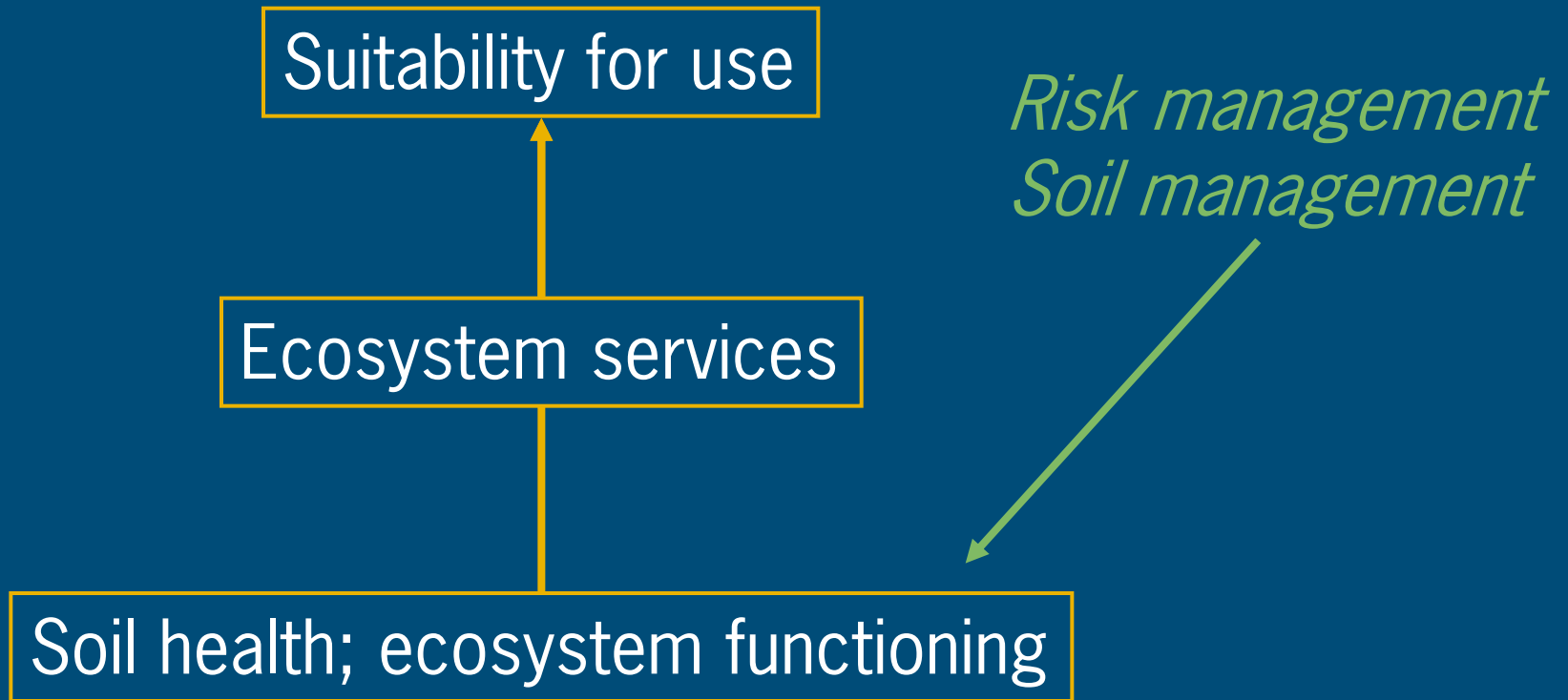
Presentation overview

- Derivation method for ES indicators for ERA
- Latest developments in indicators soil biodiversity and ES
- Recommendations and discussion

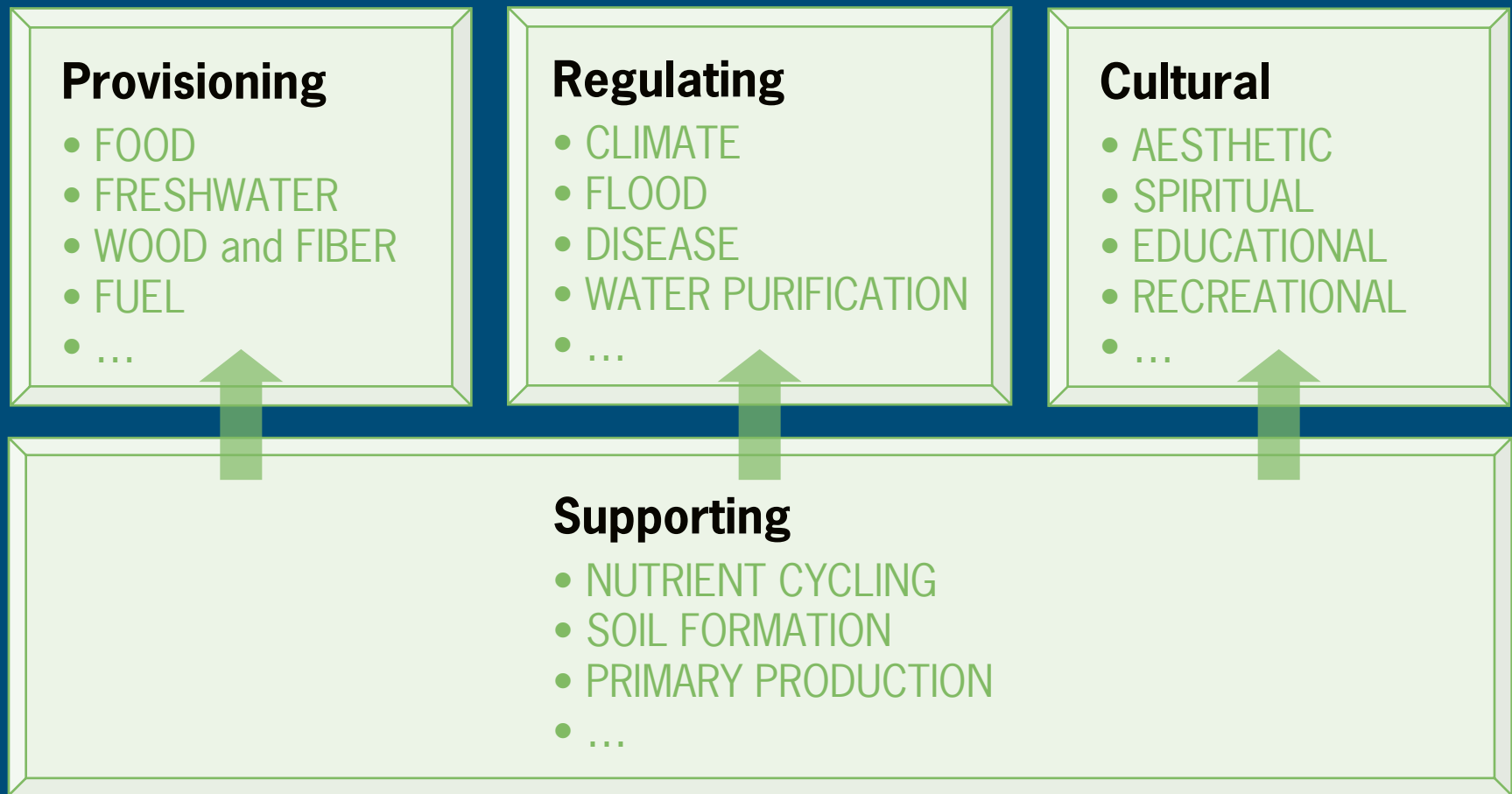
Recent developments in soil quality assessment

- Ecological risk assessment contaminated soils
 - tailor-made approaches in view of **land use**
- Remediation of contaminated land
 - clean-up target determined by **land use**
- Sustainable management of soils
 - biological references for soil quality and health
specified for land use

Land use



Ecosystem Services



After MA, 2005

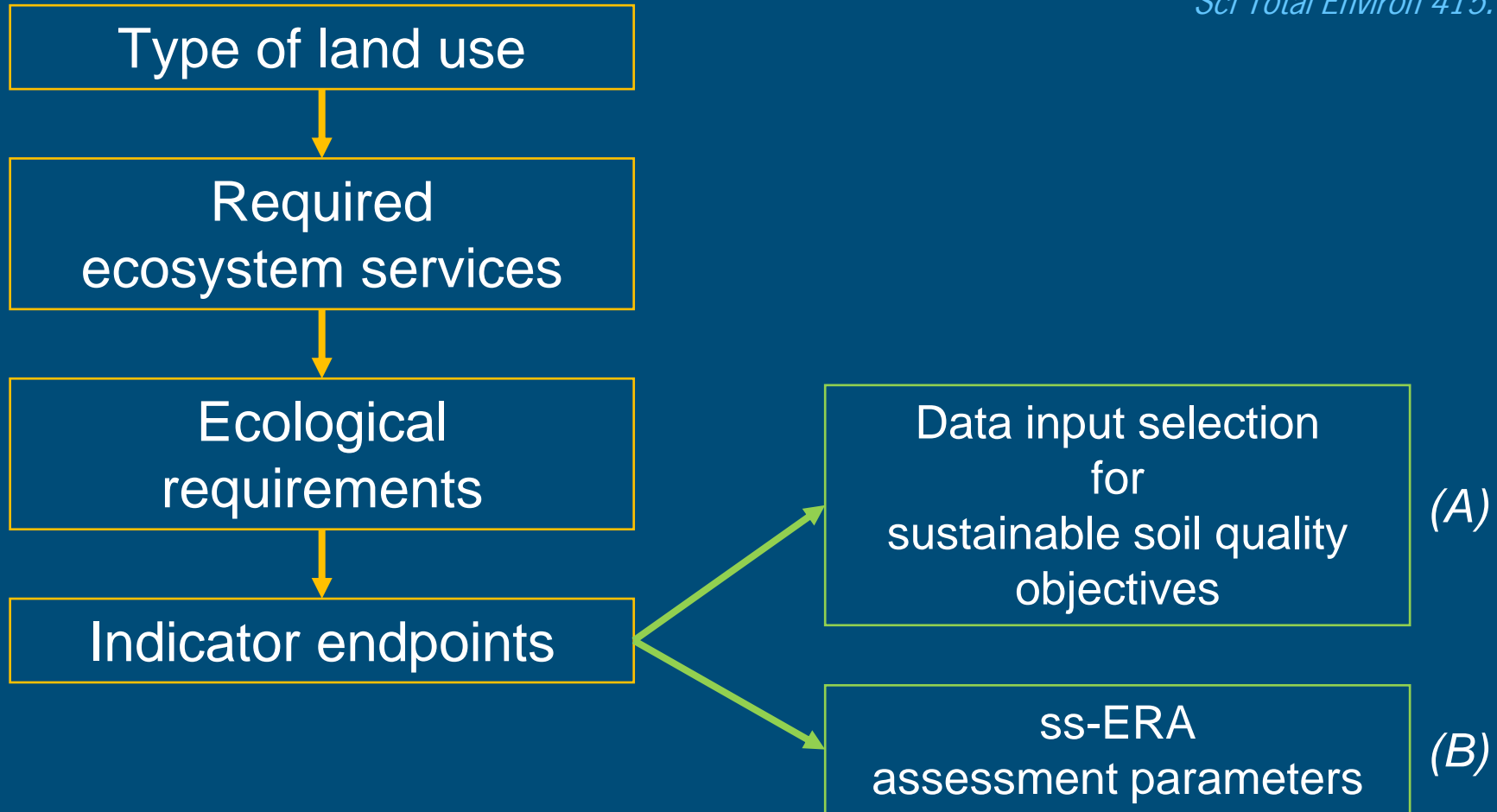
Soil ecosystem services: relevance for land use

	Ecosystem service	Land use				
		Nature	Agriculture	Parks	Allotment gardens	Gardens
Supporting	Nutrient cycling	+	+	+/-	+	+/-
	Soil formation	+	+	+/-	+/-	-
	Primary production	+	+	+/-	+	-
Regulating	Climate regulation	+	+	+/-	+/-	-
	Disease suppression	+	+	+/-	+	+/-
	Water regulation purific.	+	+	+/-	-	-

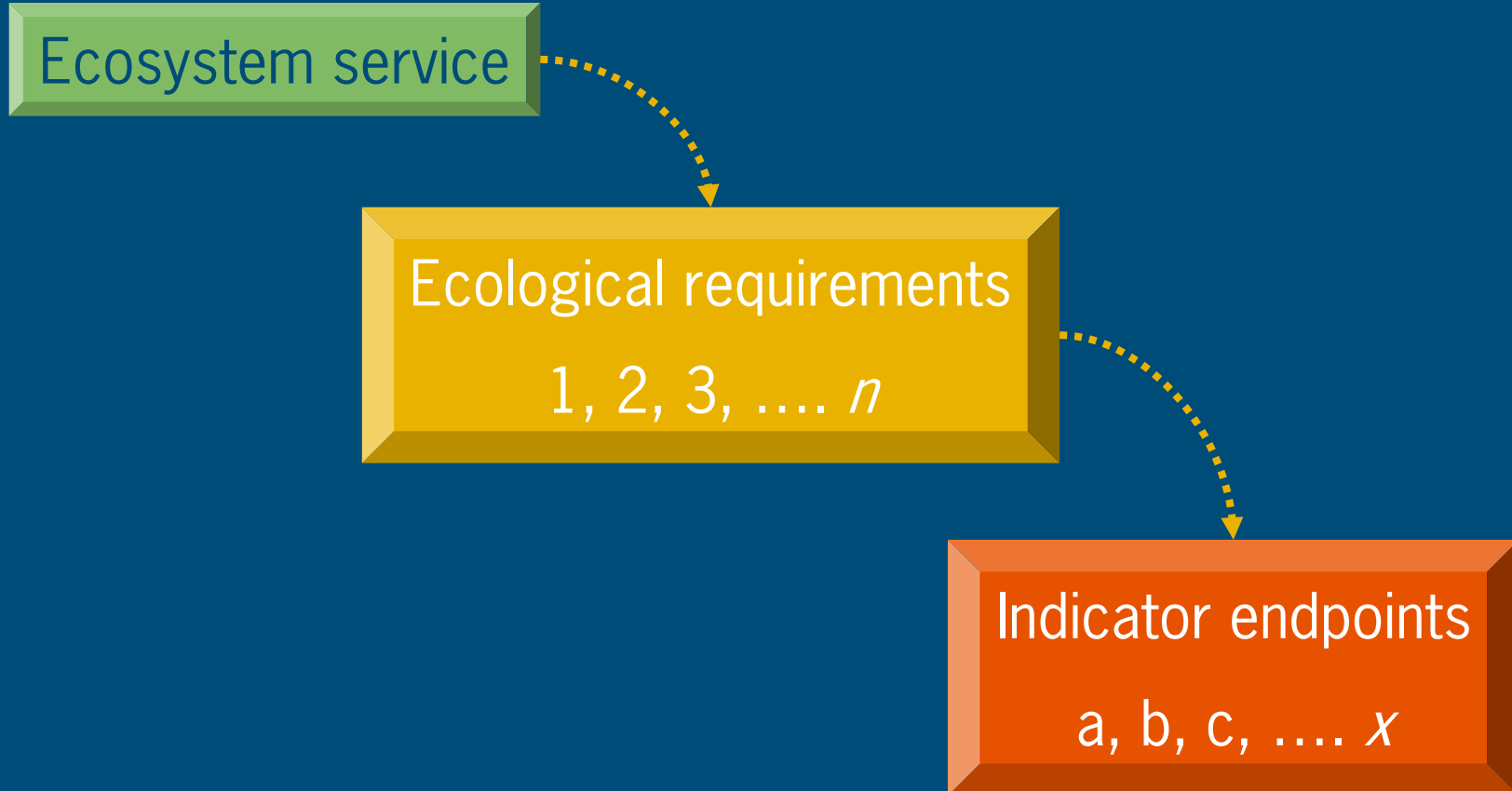
*Faber & Van Wensem 2012
Sci Total Environ 415: 3-8*

Indicator adequacy in ERA

*Faber & Van Wensem 2012
Sci Total Environ 415: 3–8*



From ecosystem service to assessment endpoint



Ecological requirements

- Ecosystem structures / processes providing ecosystem services
- Specific for ecosystem service (...)
- Minimum requirement (qualitative/quantitative) for adequate soil functioning (sustainability context)
- Assessable by adequate indicators

Indicator endpoints

- To assess state of ecological requirements
- Soil biota / processes / conditions of ecological nature
- Singular - Numerous
 - relevant for soil type / climate zone / elevation / ...
 - preference for those used in toxicity testing (field / laboratory)

Problem tree

Thomsen et al. 2012
Ecol. Indicators 16: 67–75

Level 1

Land use
1

Level 2

Ecosystem
service
1.1

Ecosystem
service
1.2

...

Ecosystem
service
1.x

Level 3

Ecological
requirement
1.1.1

Ecological
requirement
1.1.2

...

Ecological
requirement
1.1.y

Level 4

Indicator
1.1.1.1

Indicator
1.1.1.2

...

Indicator
1.1.1.z

Problem tree intermezzo

- Assessments hampered by uncertainty and ignorance
- Breakdown be broad and comprehensive
 - logical
 - Complementary (information from different sources)

Problem tree example

Ecosystem service

buffer and reaction function

complementary refinement criteria

Biological aspects

Chemical aspects

Physical aspects

Ecological requirement

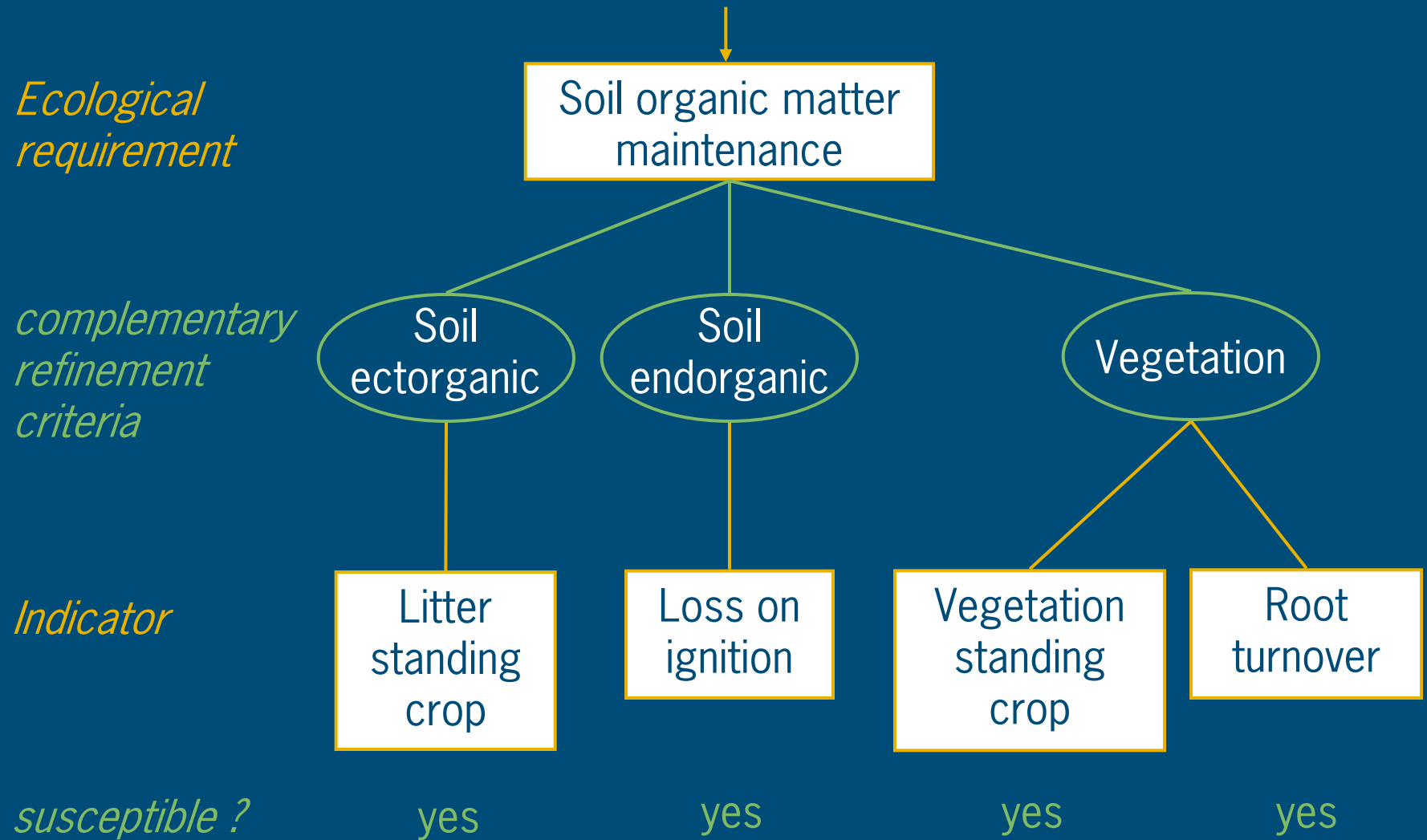
Soil organic matter maintenance

Sequestration of carbon and greenhouse gasses

Water transport and storage



Problem tree example *cont'd*



Overview ecological requirements

Ecological requirement	Soil fertility	Adaptation and resilience	Buffer and reaction function	Biodiversity	Disease suppression and pest resistance	Physical structure
Functional biodiversity	X	X	X	X	X	
Structural biodiversity, species richness	X	X	X	X	X	
Ecosystem productivity	X	X		X	X	
Organic matter fragmentation, mineralisation (<i>e.g.</i> nitrification)	X		X	X		
Soil properties (pH, CEC, aggregates, pore space, WHC, etc.)	X		X	X		X
Nutrient cycling (supply, availability, assimilation, immobilisation)	X		X	X		
Autonomic development (nature)	X	X		X		
Soil organic matter build up and maintenance	X		X		X	X
Carbon sequestration	X		X	X		
Greenhouse gases	X		X	X		
Groundwater supply and quality	X		X	X		X
Genetic variation and storage of genes		X	X	X	X	
Natural attenuation		X	X	X		
Adaptability, flexibility for use		X				
Air quality amelioration			X			
Water transport and storage			X	X		X
Landscape diversity				X		X
Soil archive (archaeological, geological)						X

Overview of indicators

Ecosystem service cluster	Ecological requirement	Indicator (examples)	
Soil fertility	Nutrient cycling	Litter mass loss rate	
		Potential nitrification	
		Available phosphate	
		K exchangeable	
		Microbial biomass and activity	
		Soil respiration rate	
		N loss to sub-root soil	
		C:N ratio	
		Functional biodiversity	Nitrifying bacteria diversity, activity
	Carbon sources utilization capacity		
	Nucleic acids microbial population characterization		
	Nematode community composition		
	Earthworms community structure		
	Key stone species		
	Soil organic matter build up and maintenance	Labile SOM fractionation	
		Fulvic/humic acids, polyphenols	
	Physicochemical soil properties	pH	
		Soil bulk density	
		CEC	
Water holding capacity			
Texture; silt and lutum fractions			
Soil aggregates			
Adaptability and resilience	Functional biodiversity	Nematode community structure	
		Earthworms community structure	
		Fungi:bacteria ratio	
		Nitrifying bacteria	
	Genetic variation	Nitrifying bacteria	
		Nucleic acids microbial population characterization	
	Species richness	Diversity indices	
		Key stone species	
	Buffer and reaction function	Soil organic matter build up and maintenance	Aneic and epigeic earthworms
			Root turnover
Labile SOM fractionation			
Physicochemical soil characteristics		CEC	
Soil structure		Number of earthworms	
Biodiversity	Functional biodiversity	Key stone species	
	Structural biodiversity	Diversity indices	
	Genetic biodiversity	Iso-enzymes	
		Nucleic acids microbial population characterization	
Disease suppression and pest resistance	Functional biodiversity (pest control)	Natural predators	
		Green vein landscape elements	
Physical structure	Soil organic matter build up	Aneic and epigeic earthworms	
		Soil structure	Soil aggregate stability
			Soil compaction

Cluster of ES →

Ecological requirement →

Indicator

Indicators are tailored according to the needs

Indicator sensitivity assessment

- Tox. data literature compilation

ES breakdown: some conclusions

- Soil fertility: many ecological requirements + indicators
- If few indicators: ignorance from data gaps?
- Indicators lacking data :
 - Actinomycetes, Archaea
 - autotrophic bacteria
 - pollinators with soil dwelling larvae
 - Lichens, symbionts
 - faunistic and floristic genetic diversity

Toxicity data review

Ecosystem service	Ecological requirement	Indicator (+unknown)	Susceptible (+unknown)	Tox. data chlorpyrifos (Tox + non tox)
Soil fertility	8	70	54+6	14+9
Flexibility and perseverance for land use	4	16	16	0
Buffer and reaction function	11	30	20	3+1
Disease suppression and pest resistance	1	6	6	0
Biodiversity	2	6	6	1+1
Physical support	5	6+2	6+2	0

New developments in ES Indicators



Ecological Function and Biodiversity Indicators in European Soils

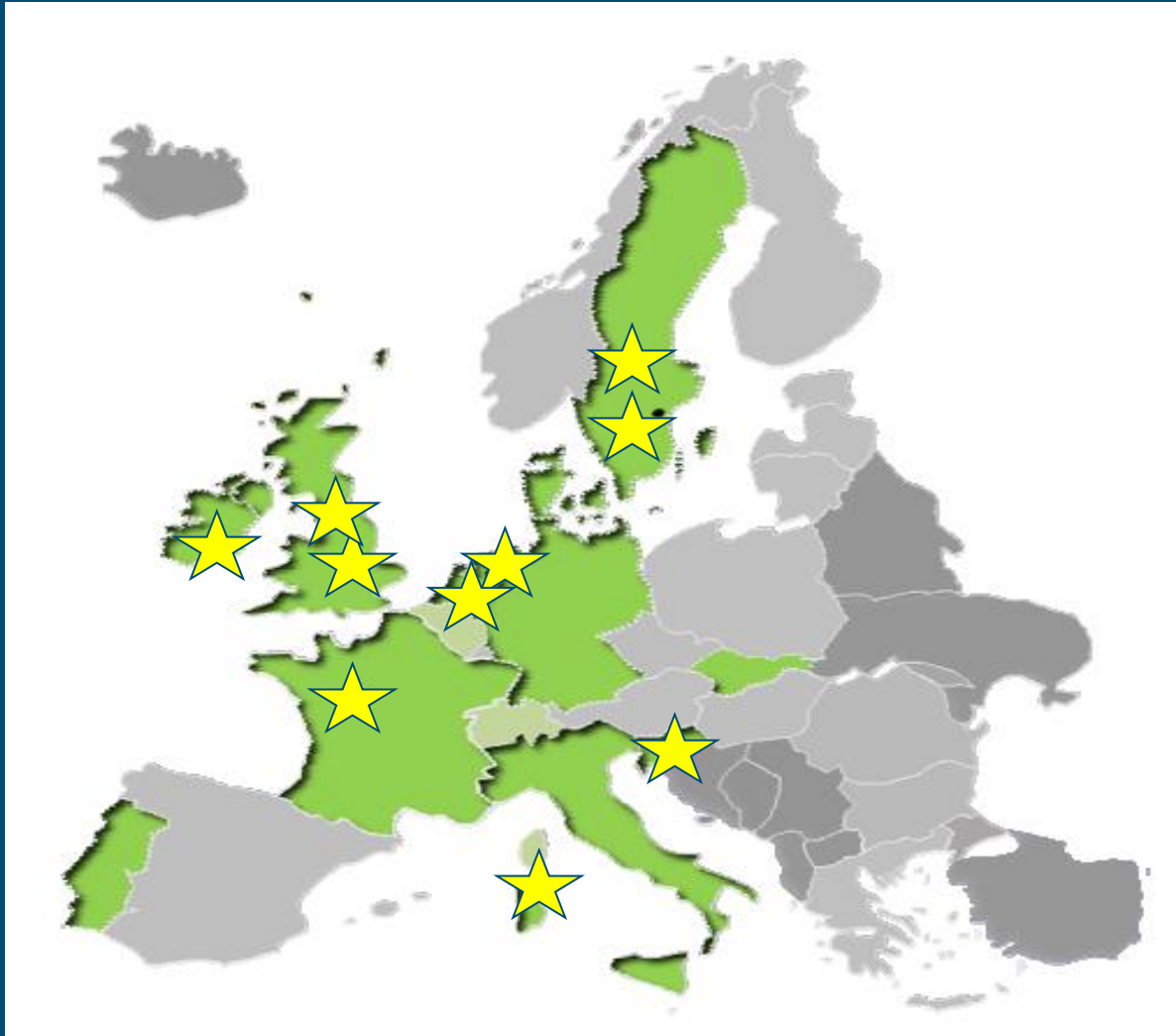
Aims:

- Characterisation of European soil biodiversity
- Determination of relations between soil biodiversity, soil functions and ecosystem services
- Design of policy-relevant and cost-effective indicators for monitoring soil biodiversity and ecosystem services

Specific indicator tasks

- Recommend potential indicators for biodiversity in different climatic regions
- Incorporate novel indicators resulting from the novel molecular biology methods being undertaken
 - nucleic acid based methods
- Evaluate indicators at selected long-term observatories
- Assess applicability to the key ecosystem services
- Ensure policy relevance by mapping to threats

The EcoFINDERS sites



Long-term
observation sites

- climate
- soil type
- land use

Selecting indicators

Not starting from scratch

■ Published papers

- Bispo et al. 2009 (ENVASSO)
- De Bello et al. 2010; Feld et al. 2009, 2010 (RUBICODE)
- Ritz et al. 2009 (UK-Soil Indicators Consortium)
- Aalders et al. 2009 (Scottish Government initiative)

■ On-going programs

- UK: SNIFFER; DEFRA; Royal Commission; ECN; Soil Indicators Consortium; Countryside Survey
- NL: BiSQ

Practice in EcoFINDERS

Based on previous experience:

- Reduce ## indicators (i.e. >180 by Ritz et al)
executive decision by small number of experts
- Indicators prioritized to defined objectives of project
biodiversity and ecosystem services
- Logical sieve approach to order potential indicators
larger survey within the project as a whole
- Align final list
expert judgment

Logical sieve – score sheet

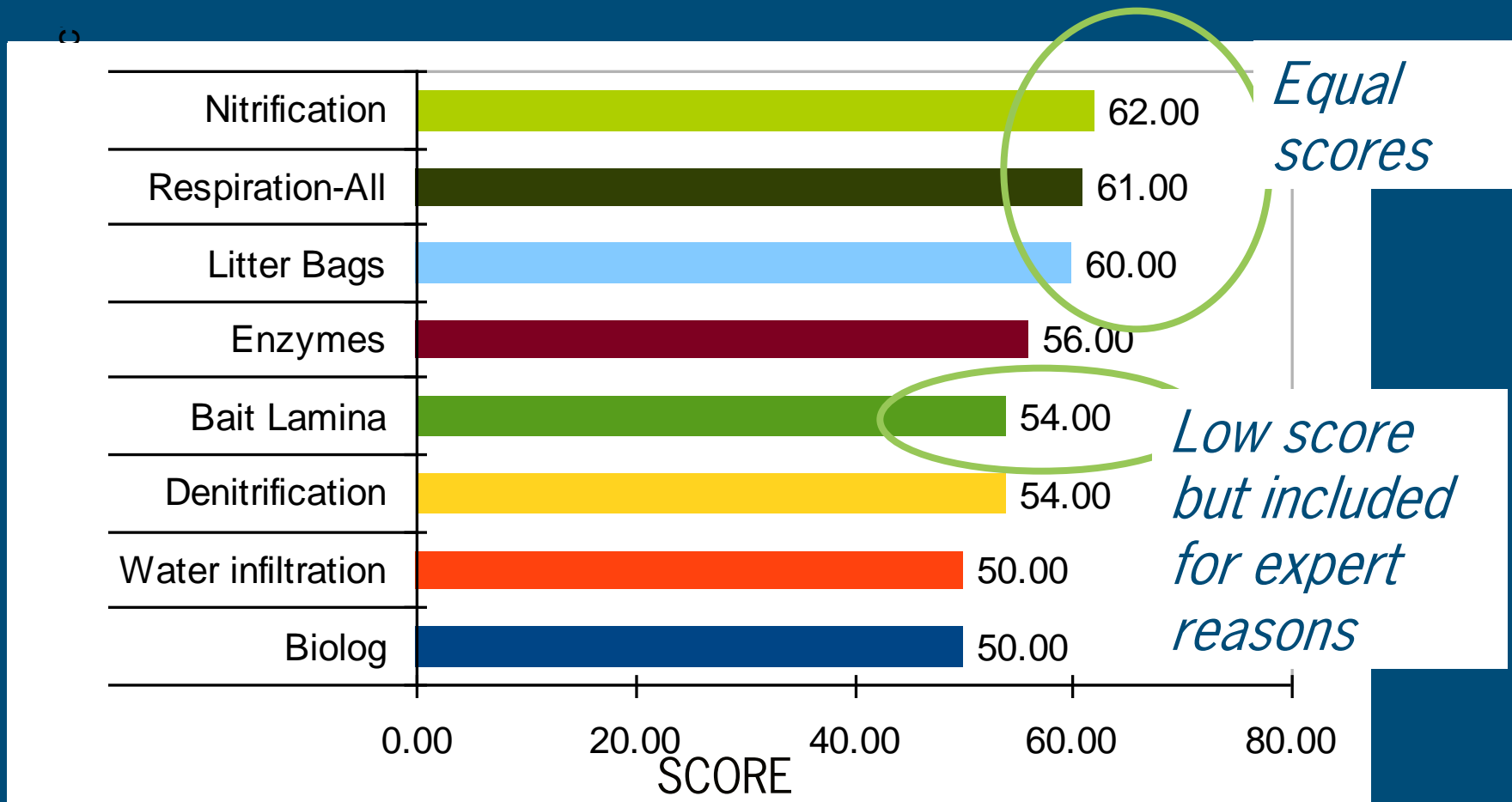
Criteria for indicators

Scoring	measurement [Av]		Labour intensity		Appropriate to measure		Sensitivity -[av]			Understand-able
	Any lab	skills	Field	Lab	biodiversity	eco services	soil type	land use	disturbance	
	5	all	general	high	high	high	high	high	high	
4	Major-ity									
3	most	moderate	med	med	med	med	med	med	med	
2	few									
1	v. few	specialist	Low	Low	low	low	low	low	low	
<p>Fauna</p> <p>Earthworms Morphology</p> <p>Earthworms Molecular</p>										

1-5 scale

The indicators

MCA scores are not everything



Final list of indicators

	Ecosystem service	
	Insurance	Nutrients, Water Regulation, etc
	Biodiversity	Function
Fauna	Nematodes	Nematodes
	Enchytraeids	Earthworms
	Collembola	
Microbe	Protozoa (molecular)	Fungal biomass - ergosterol
		F:B ratio and structure - PLFA
	Bacteria/ Archaea/ Fungal TRFLP	
Function		Labile C+N
		Respiration: MicroResp Resilience
		Bait lamina
		Water infiltration
		Nitrification

Plan for indicators

- Evaluate indicators at EcoFINDERS sites
 - Sensitivity to the changes imposed at the sites
 - Economic and man-power requirements
 - Cost-effectiveness
 - Ease of interpretation

Recommendations to policy

- Purpose is key to selection
tailor-made indicator sets
- Trade/off between number and accuracy, and costs
best compromise case by case
- “Stock index” for ecosystem service provision
quick and dirty impression, identify sites for further analysis
underlying info required for interpretation
- Long-term data for ‘benchmarking’
- Standardisation for comparability and quality control

For discussion

Guidance?

- Sets of adequate indicators
- The process of selection

Acknowledgement

European Commission,
FP6 Integrated Project 'NOMIRACLE' / FP7 Integrated Project 'EcoFINDERS'



The Dutch Ministry of Economic Affairs, Agriculture, and Innovation,
KennisBasis, KB-14-Duurzame ontwikkeling van de groenblauwe ruimte

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