Land use, soil biodiversity and the sustainable provision of ecosystem services

Insights from the SOILSERVICE project

Stefan Hotes and Katarina Hedlund

Justus-Liebig-University, Giessen, Germany
and Lund University, Lund, Sweden

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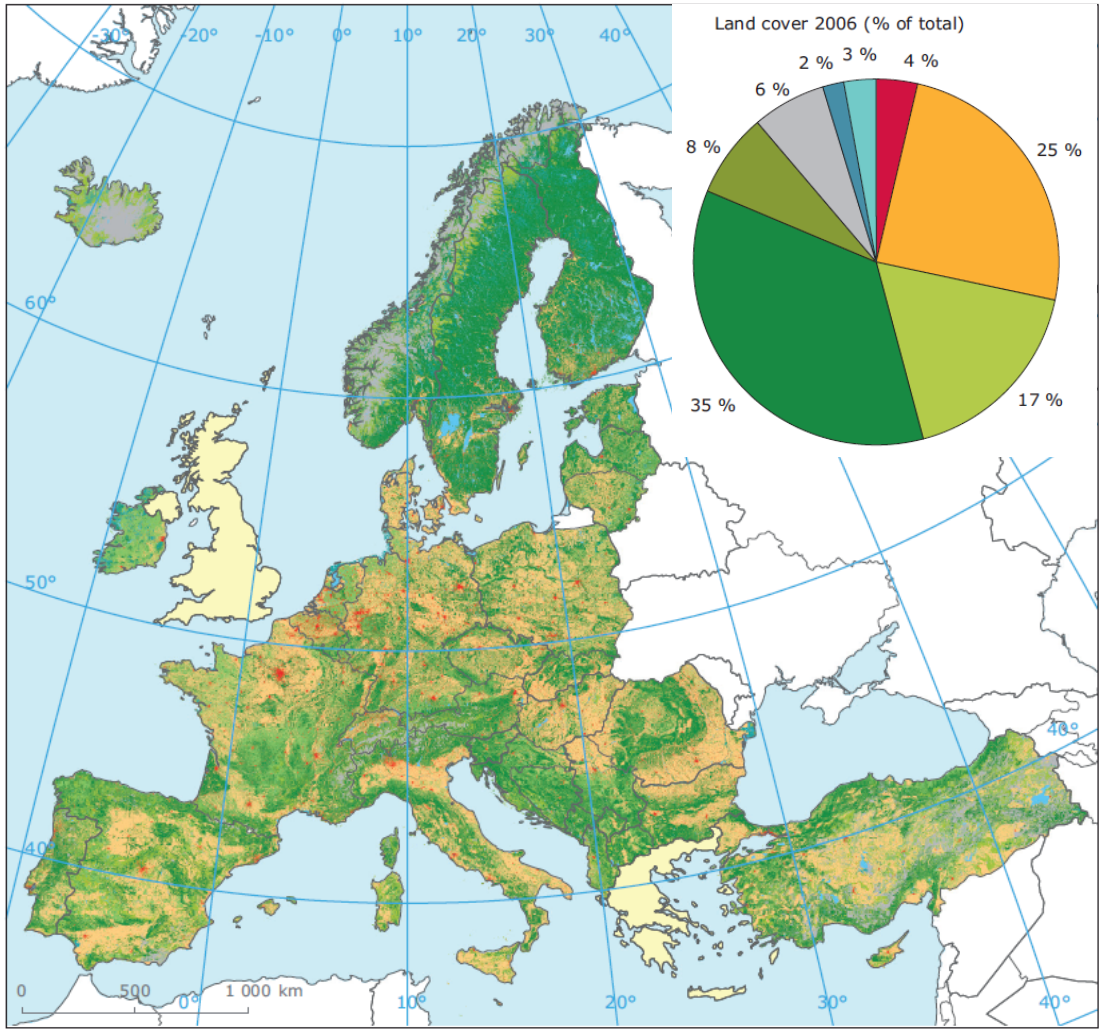
- European policies and soil

Land use in Europe



Source: EEA/ETC-LUSI, 2010.

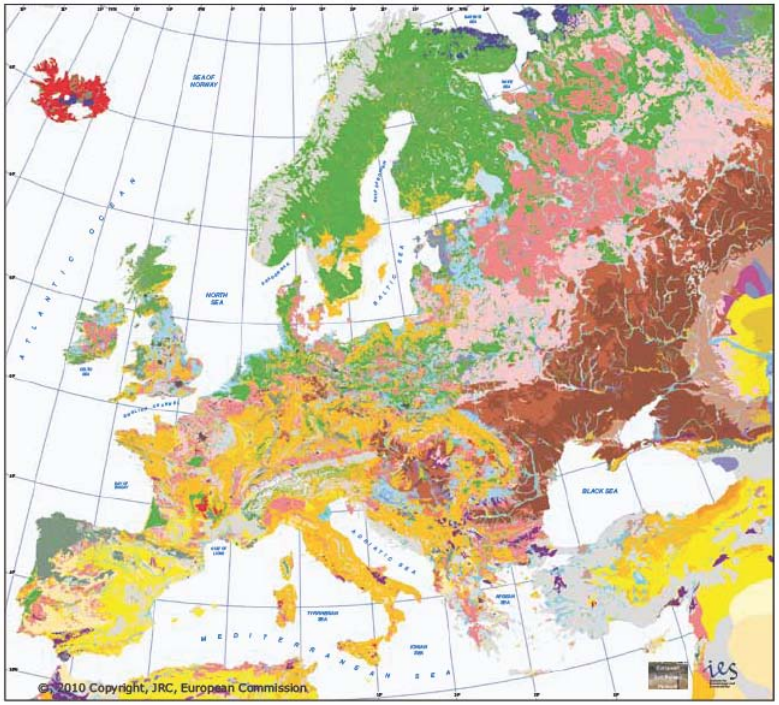
Land use types are changing, although at a decreasing rate:

1990 – 2000: 0.2 %/yr

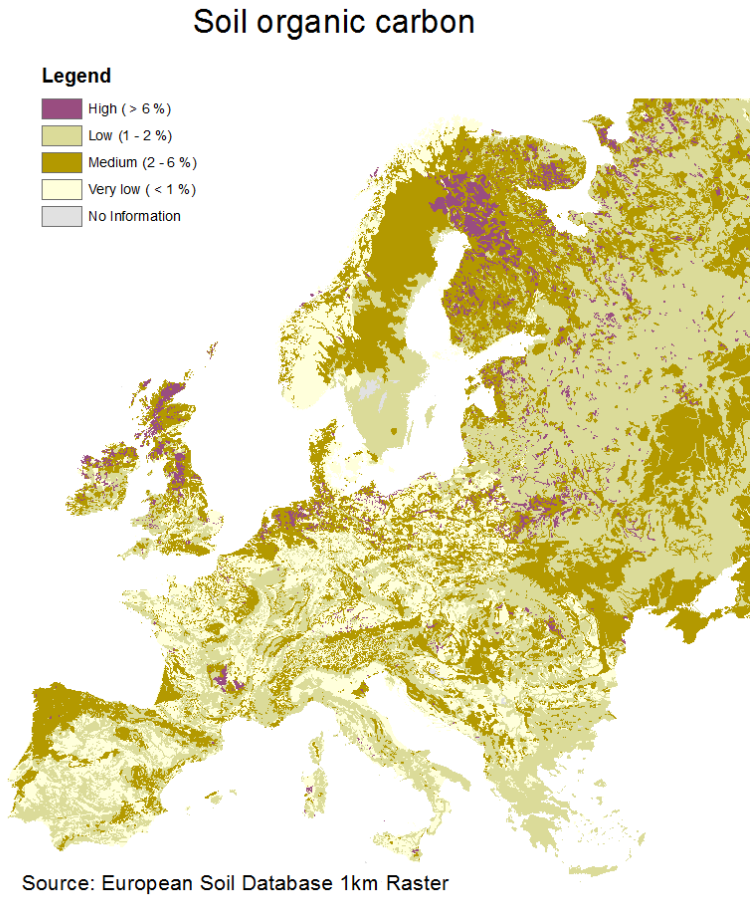
2000 – 2006: 0.1 %/yr

Soils in Europe

Soil types



Soil functions



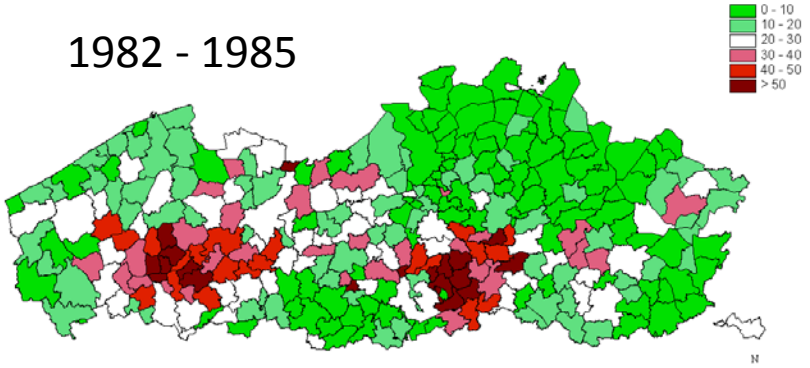
Source: European Soil Database 1km Raster

Threats to soils and soil functions

Erosion

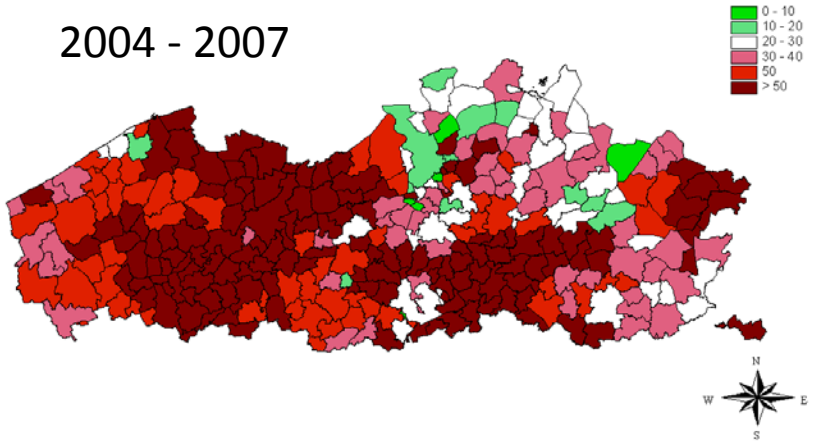
Loss of organic matter

1982 - 1985

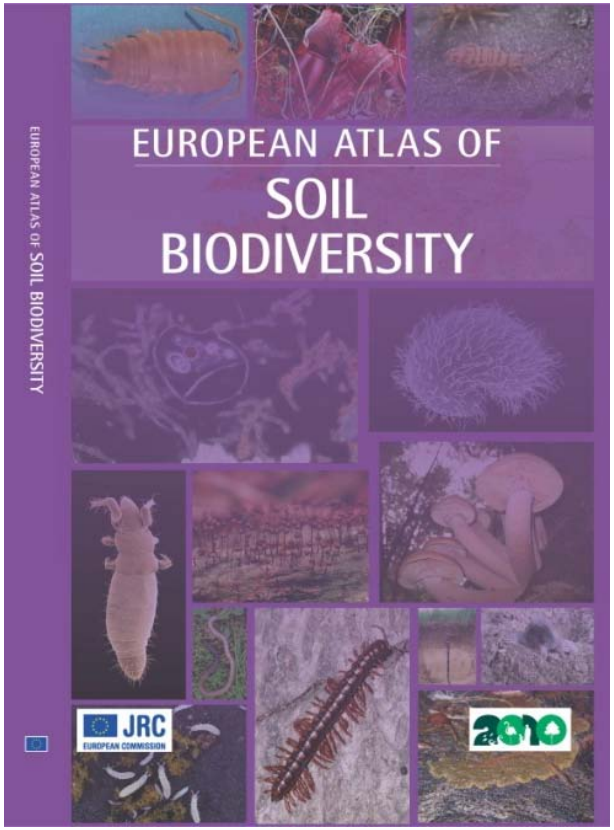


Compaction

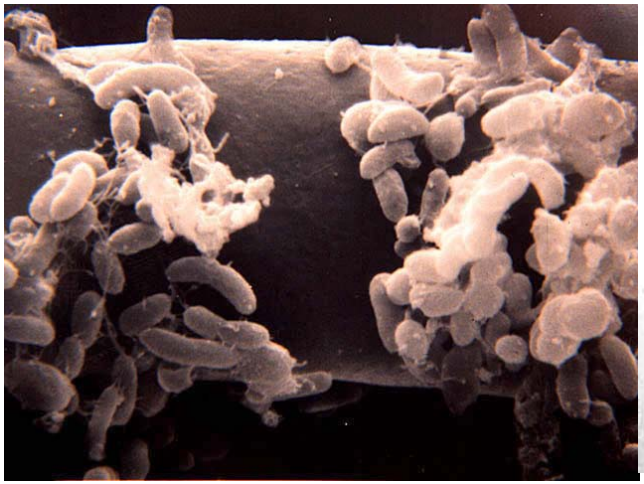
2004 - 2007



Soil biota in Europe



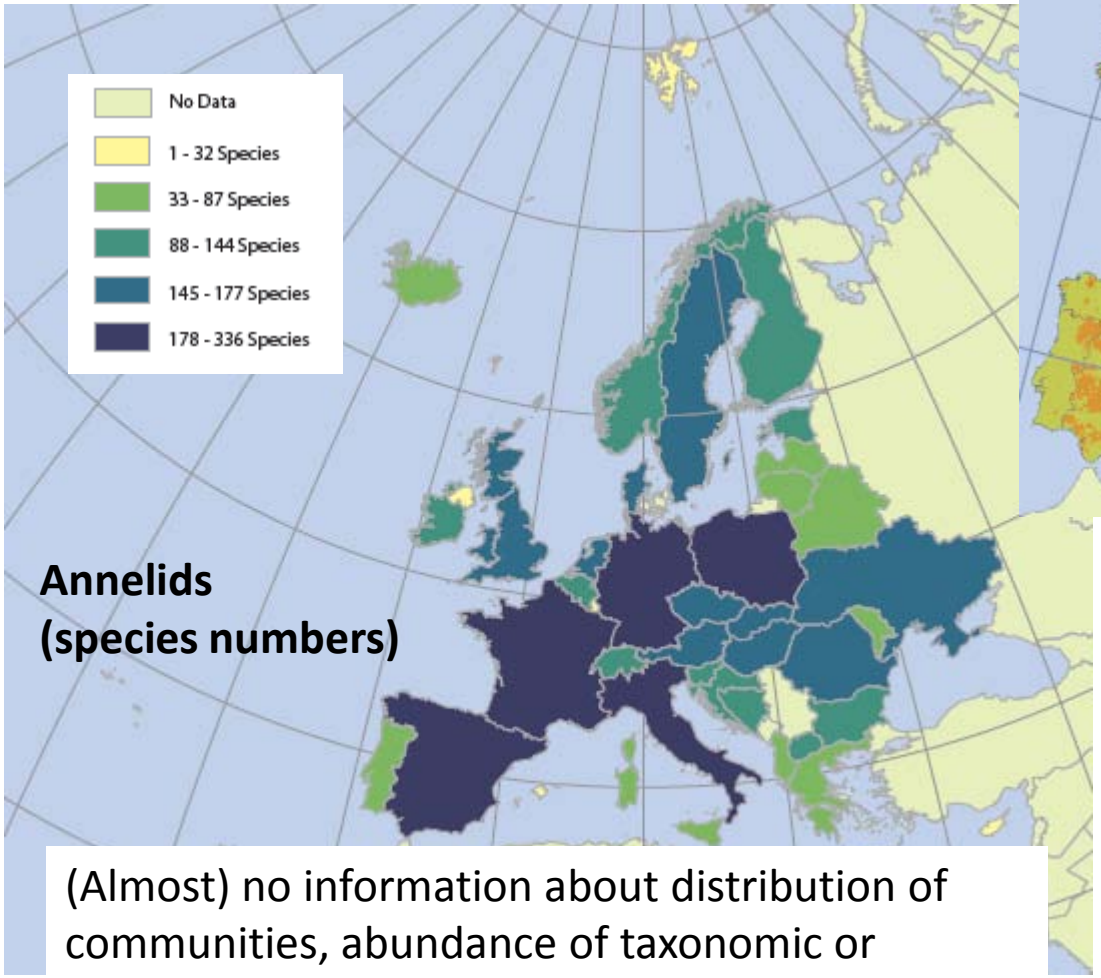
Jeffrey et al. 2010



Challenges:

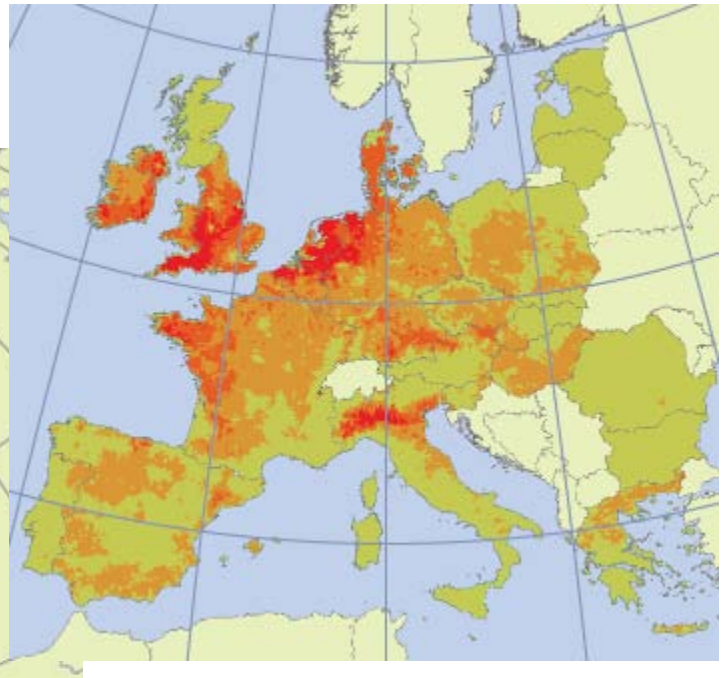
- **spatial and temporal scales**
- **high variability**

Soil biota in Europe



Annelids (species numbers)

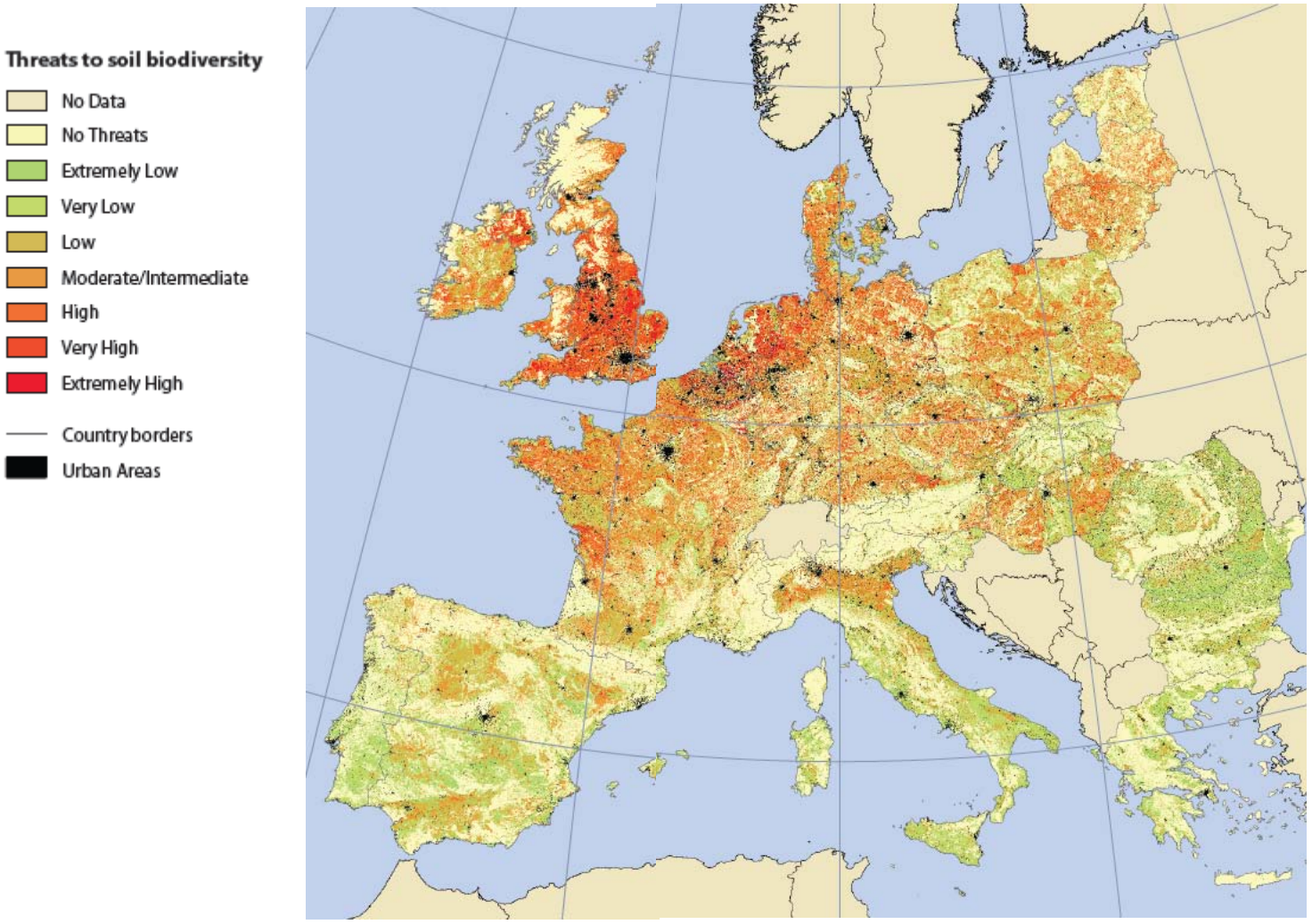
(Almost) no information about distribution of communities, abundance of taxonomic or functional groups



Threats to soil biodiversity: Agricultural intensity (estimated from nitrogen load data)

Source: Jeffery et al. 2010

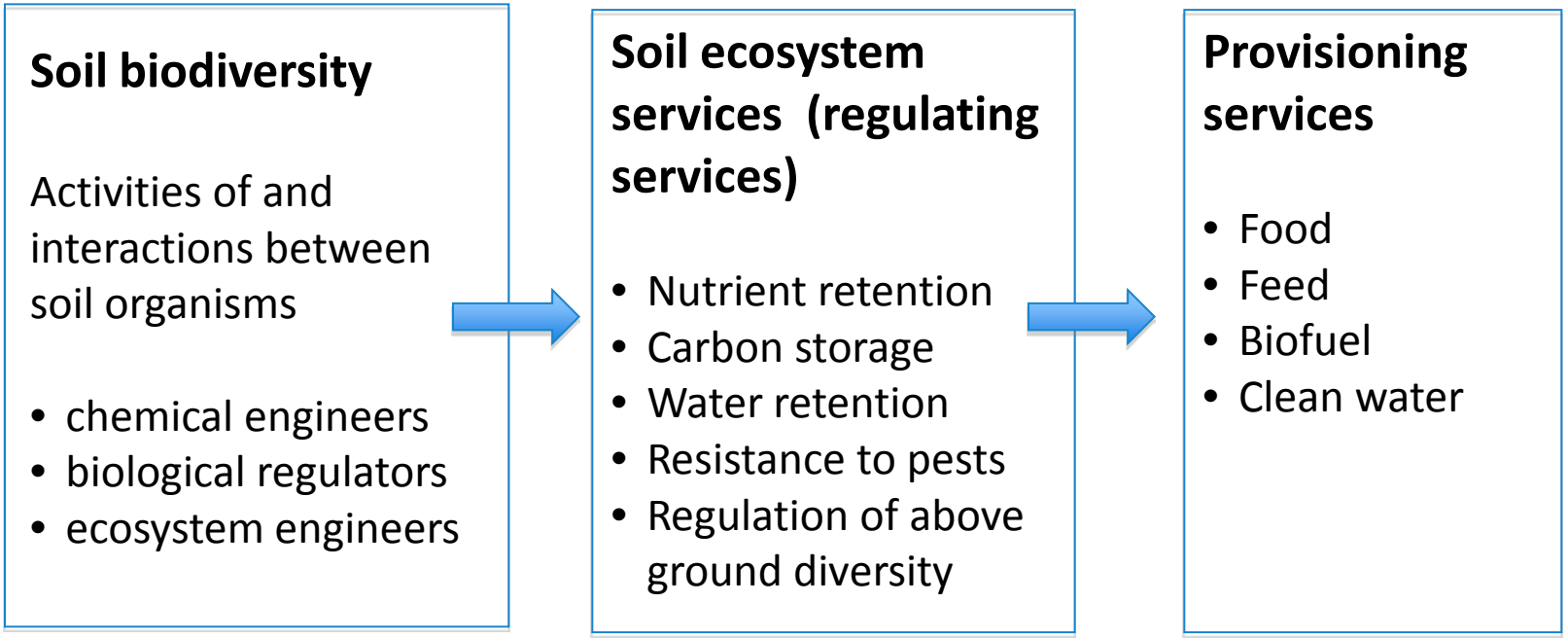
Potential threats to soil biodiversity



Source: Jeffery et al. 2010

The SOILSERVICE project

- European soil biodiversity is pivotal for delivering regulating and provisioning ecosystem services
- Increasing demand for ecosystem services exacerbates trade-offs among and within groups of services
- Adequate valuation of ecosystem services can help optimize service provision



The SOILSERVICE project

- Link soil biodiversity and ecosystem services in agricultural production
- Value soil ecosystem services as a part of farmers economy
- Predict future land use changes, based on farmers economy and sustainable use of soils

The SOILSERVICE project

Soil biodiversity

Ecosystem services

Agricultural land use:

crop rotation
biofuel crops
pastures

Link diversity to functions:

biodiversity
food webs

Quantify ES:

nutrient retention
carbon retention
resistance to pests
stability of services

The SOILSERVICE project

Conflicting demands of land use, soil biodiversity and the sustainable delivery of ecosystem goods and services in Europe

WP 7 Project management and Dissemination

WP 1 Retention of nutrients	**WP 2 Regulation of atmospheric gases**	**WP 3 Control of pests and invasive species**	**WP 4 Thresholds for vulnerability of ecosystem services and diversity**	**WP 5 Economic valuation of soil ecosystem services and design of effective management policies**	**WP 6 Scenarios and strategies of promoting sustainable use of ecosystem services**

11 partner institutions in Sweden, Finland, Denmark, the UK, the Netherlands, Germany, the Czech Republic and Greece

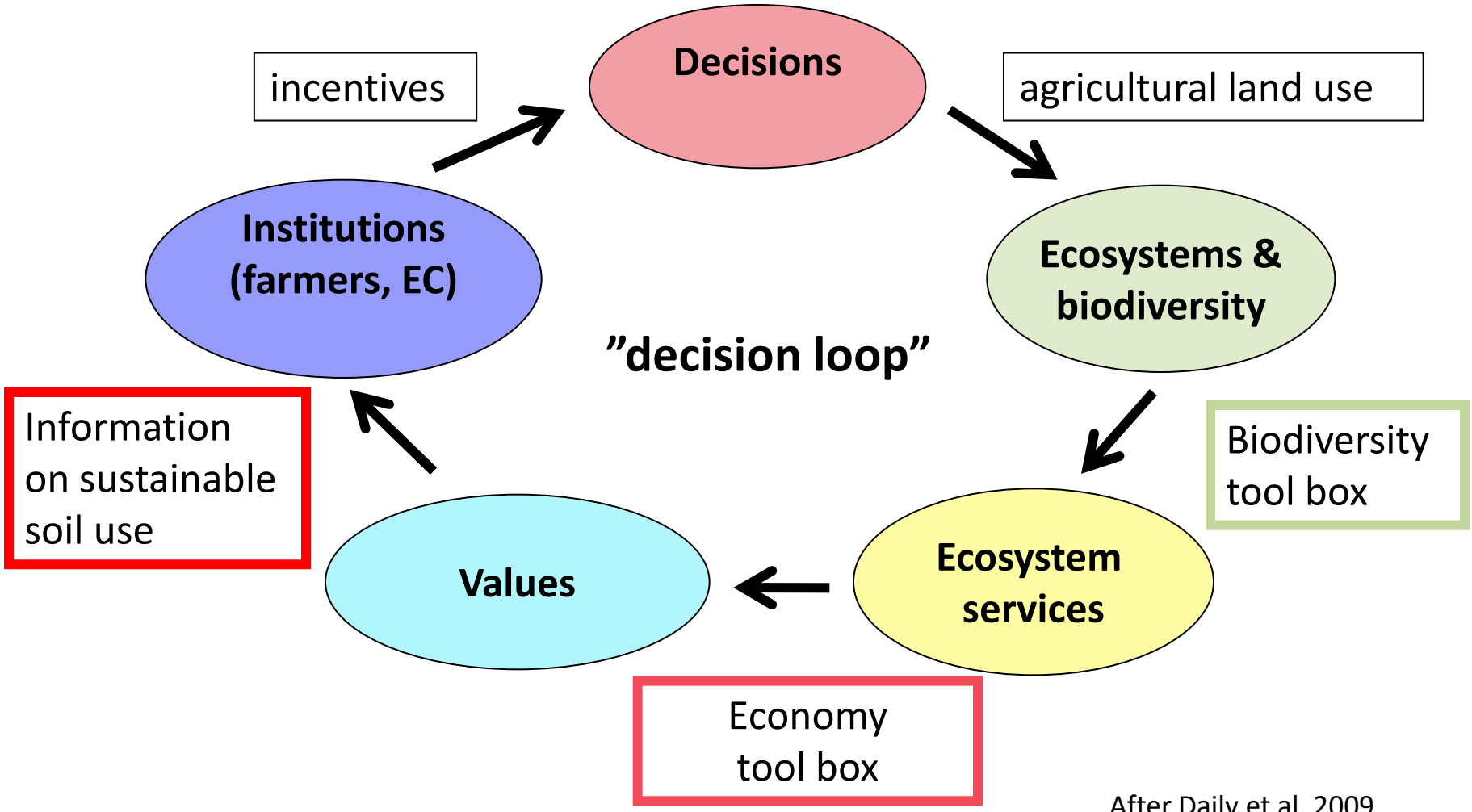
The SOILSERVICE project

SOILSERVICE study regions

			Domin. soil type FAO WRB
Sweden	–	Scania	Calcaric Cambisol (86 %)
England	–	South East	Chromic Luvisol (46 %)
Czech R.	–	Visocina	Gleyic Luvisol (53 %)
Greece	–	Kria Brisi	Calcaric Fluvisol (99 %)

Sampling sites along a gradient from intensive crop rotation to pastures in each region

The SOILSERVICE project

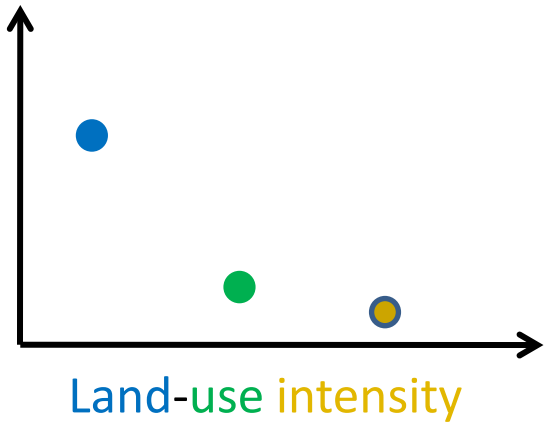


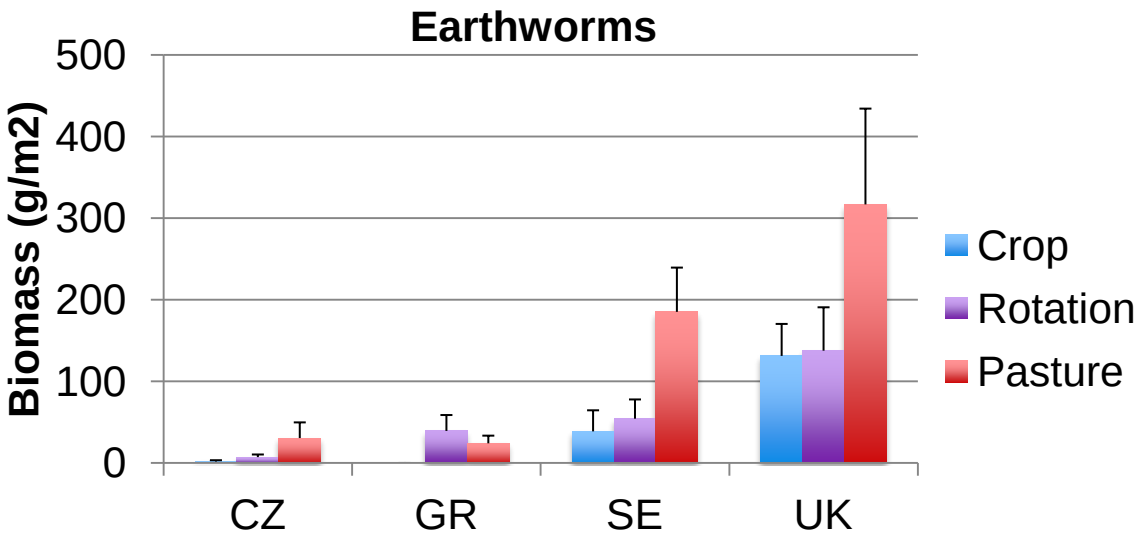
After Daily et al. 2009

Land use and soil biodiversity

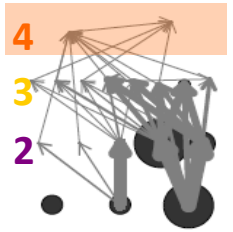
Land-use intensity affects e.g. :

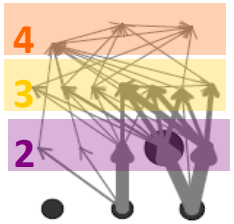
- Biomass of fungi and bacteria
- Number of nematodes
- Number of Enchytraeid worms
- Species diversity of Collembola
- Biomass of earthworms

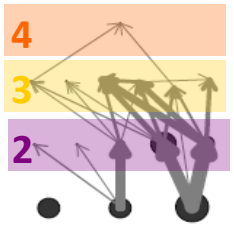




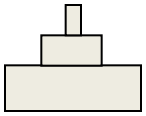
Land use and soil biodiversity



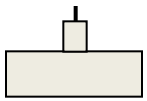




low intensity



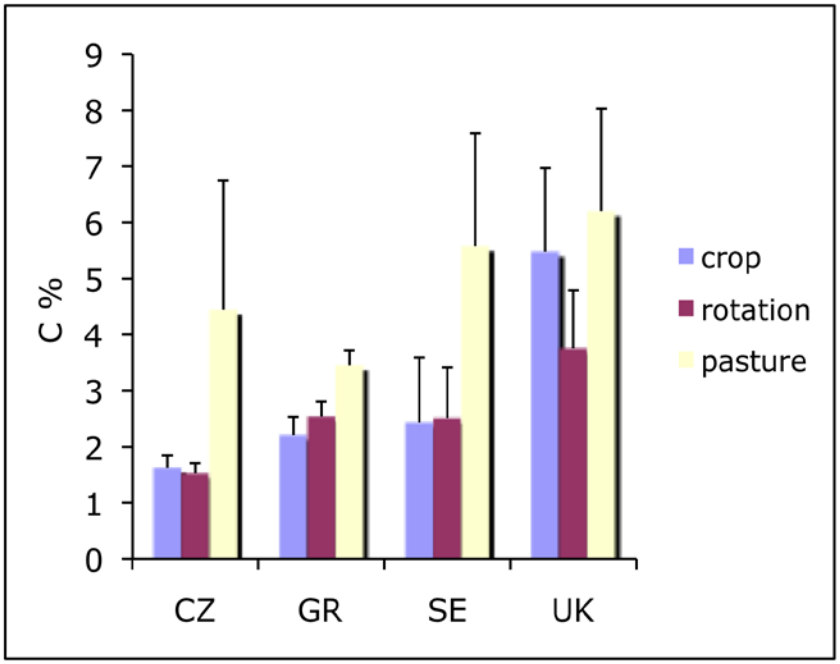
high intensity

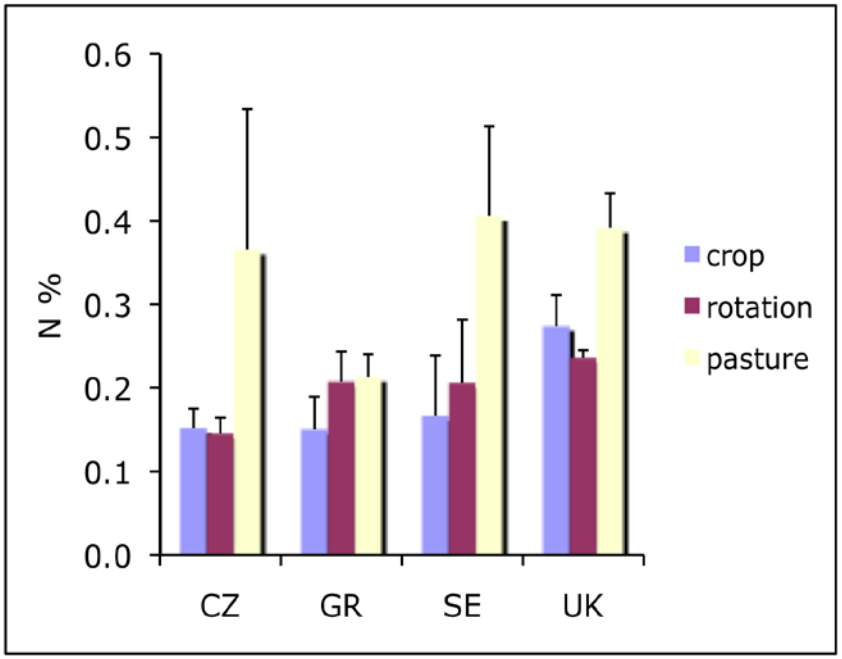


- Lower food chain length
- Steeper biomass pyramid
- Lower C & N mineralization rates

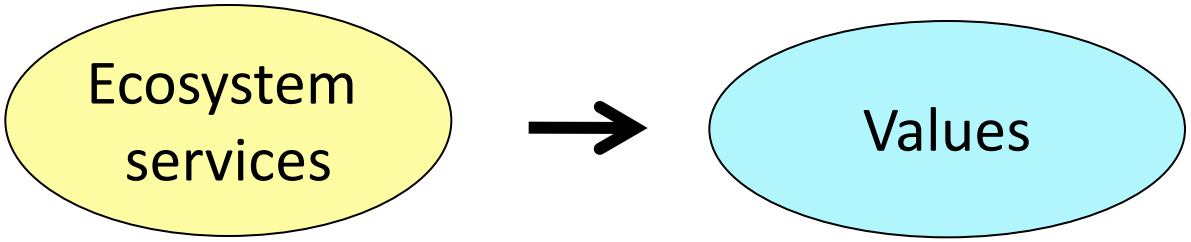
Land use and ecosystem functions

Carbon & nitrogen retention





Valuation of ecosystem services



- Focus on provisioning and regulating ecosystem services
- Monetary valuation using market prices
- Develop production functions of services
- Model effects of agricultural practices on yield
  - N response
  - Impact of changing soil C stock

Valuation of ecosystem services

1) Static problem
   - desirable flows of services
   - Optimal farming intensity
   - don’t consider costs of getting there

2) Long-term (Dynamic problem)
   - desirable flows of services in the future
   - sustainability of farming system

3) Uncertainty about future (Stochastic problem)
   - desirable insurance against loss of services
   - Consider benefits to both current and future generations

Valuation of ecosystem services

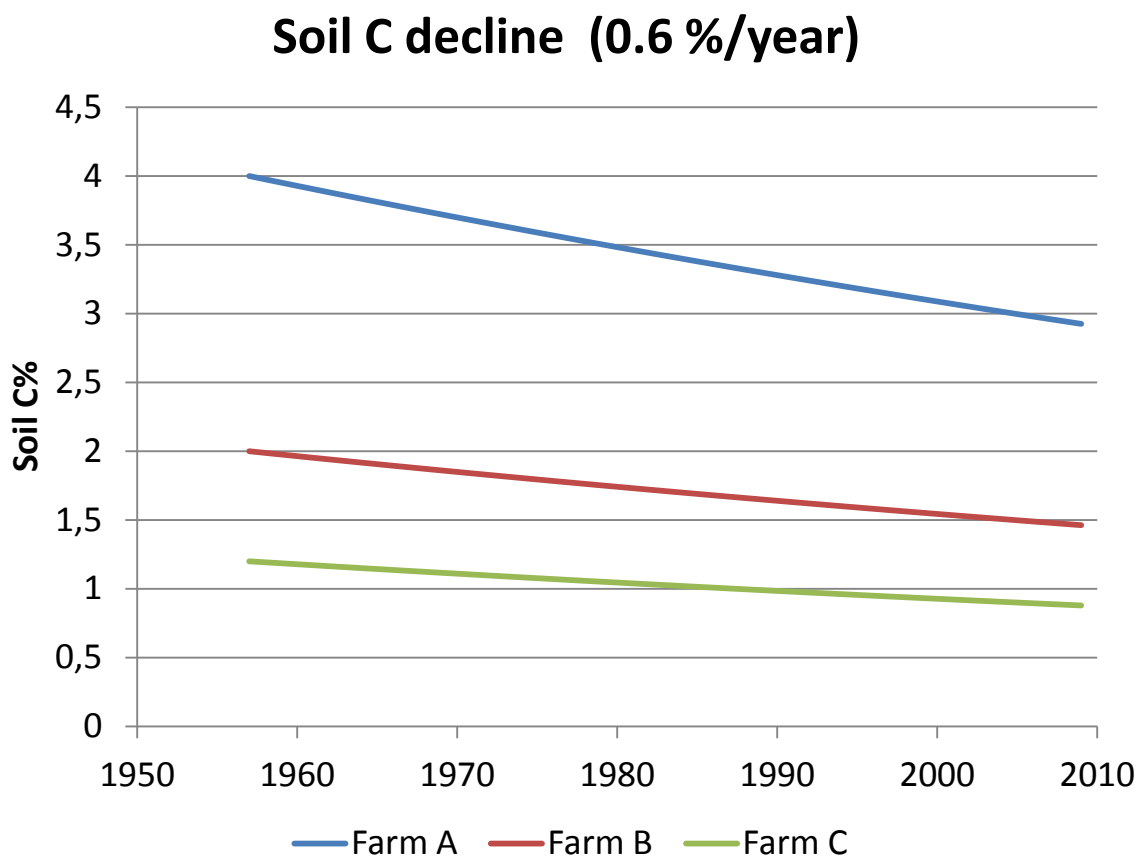
Soil processes are slow compared to economic processes

Prediction of farmers economy in the future needs:

- Long term data of the past
- Dynamic models of ES functions
- Regional economic model of farmers economy
- Scenarios of future development

Valuation of ecosystem services

Long-term data sets



Valuation of ecosystem services

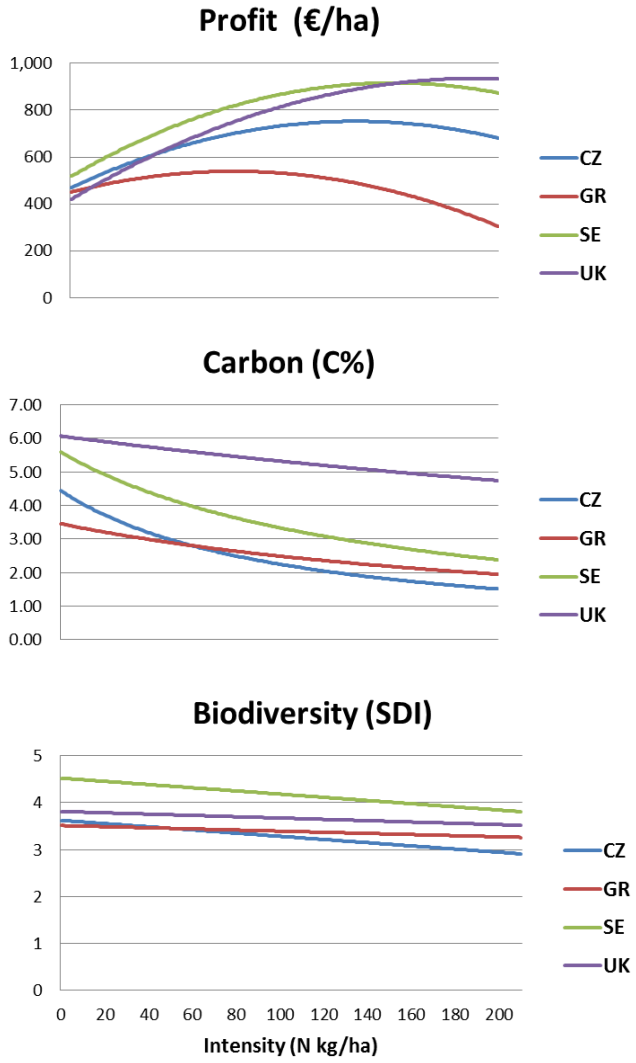
Long-term data sets

Carbon at LTEs in Europe

Management	C decline %/yr	LTO
FYM/ley	0.3-0.6	Askov DK
ley/ no ley	0.2-0.8	Scania S
no FYM	0.2-1.7	Rothamsted UK

Management	C increase %/yr	LTO
Straw addition		
12 ton/ha	0.3	Askov DK
FYM 35 ton/yr	0.4	Rothamsted

Valuation of ecosystem services



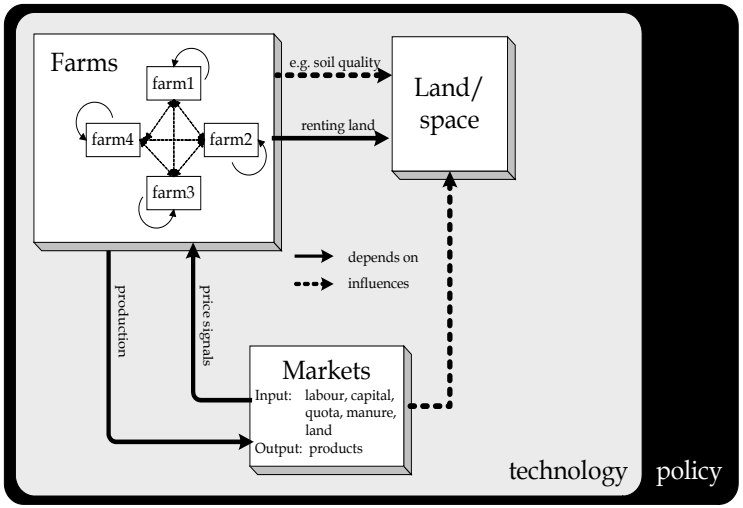
Static model results for increasing N input

- Profits saturate or decrease
- Carbon content decreases
- Biodiversity (Shannon diversity index of groups in food web models) decreases

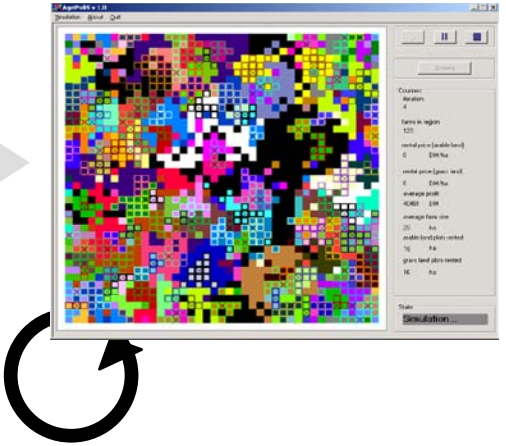
with increasing nitrogen input

Valuation of ecosystem services

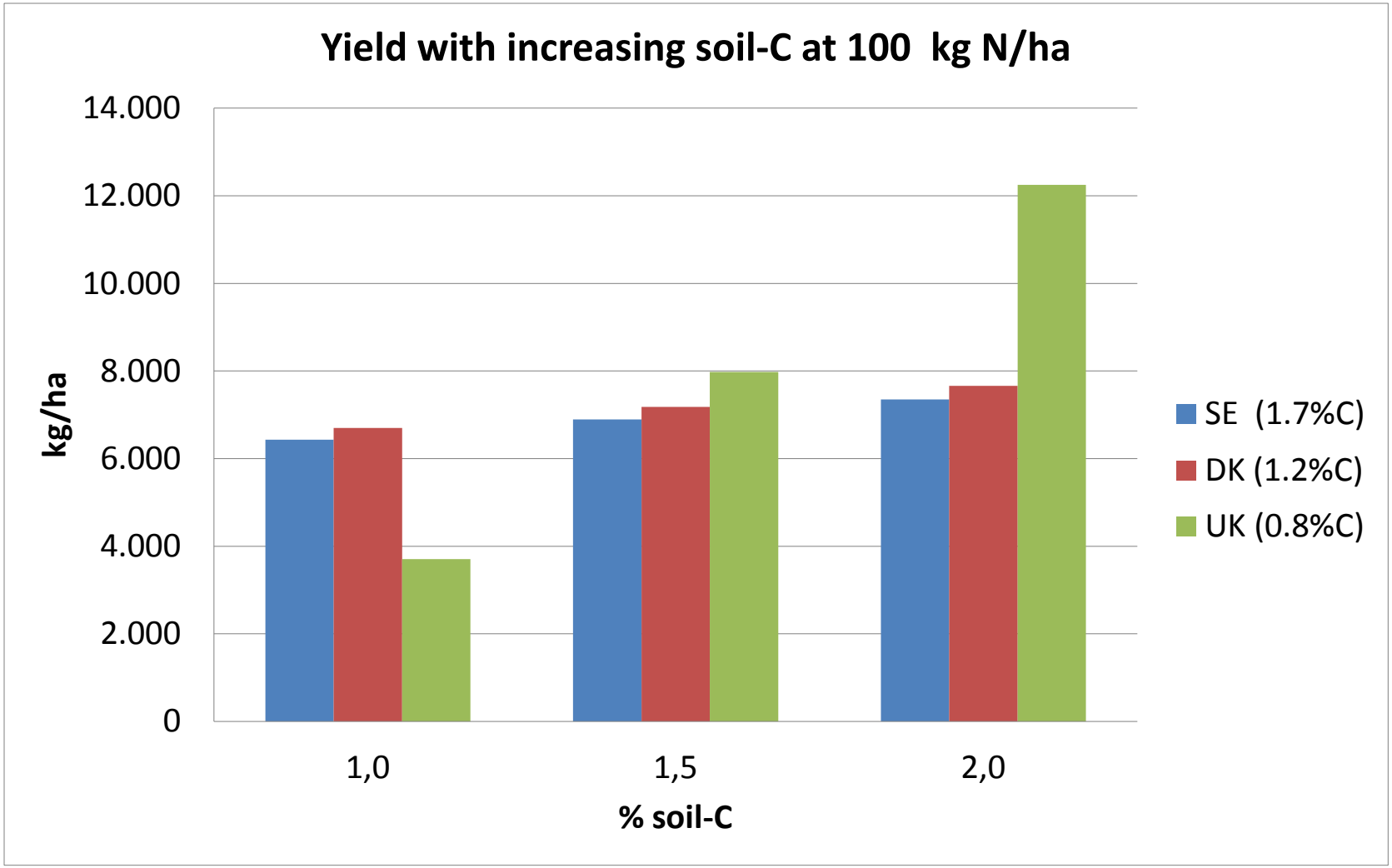
Modelling tool AgriPoliS: agent-based model of agricultural region



AgriPoliS



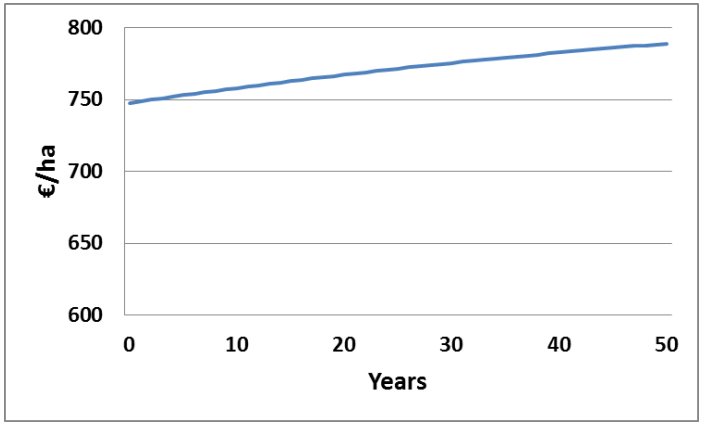
Valuation of ecosystem services



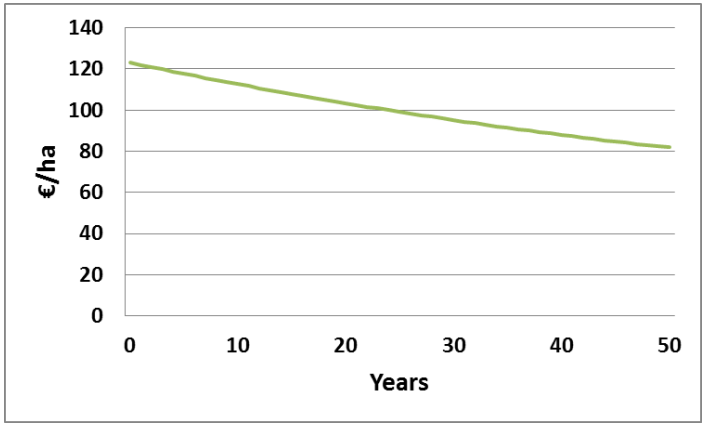
Valuation of ecosystem services

Dynamic model of economic effects of increased carbon sequestration

Profits over time



Subsidies over time

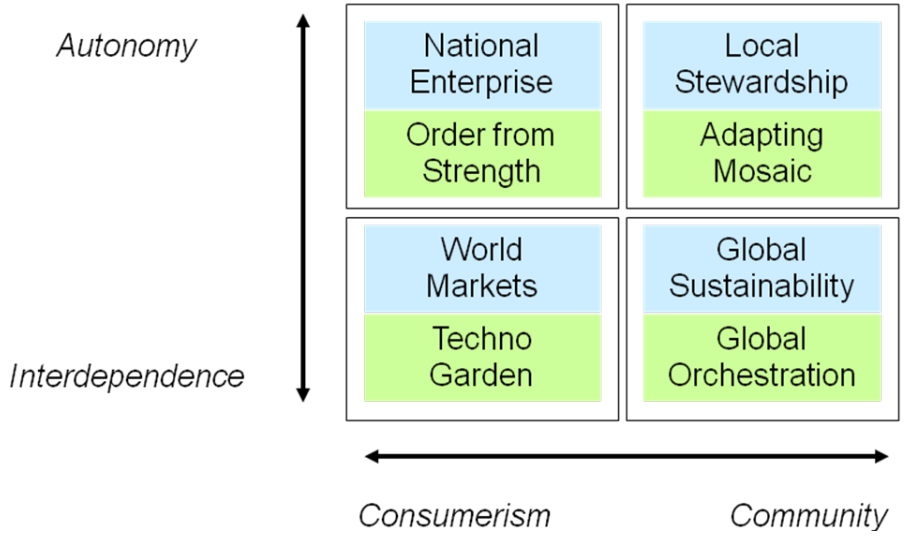


Scenarios and ecosystem services

Global

IPCC/SRES (2000)

Millennium Ecosystem Assessment (2005)



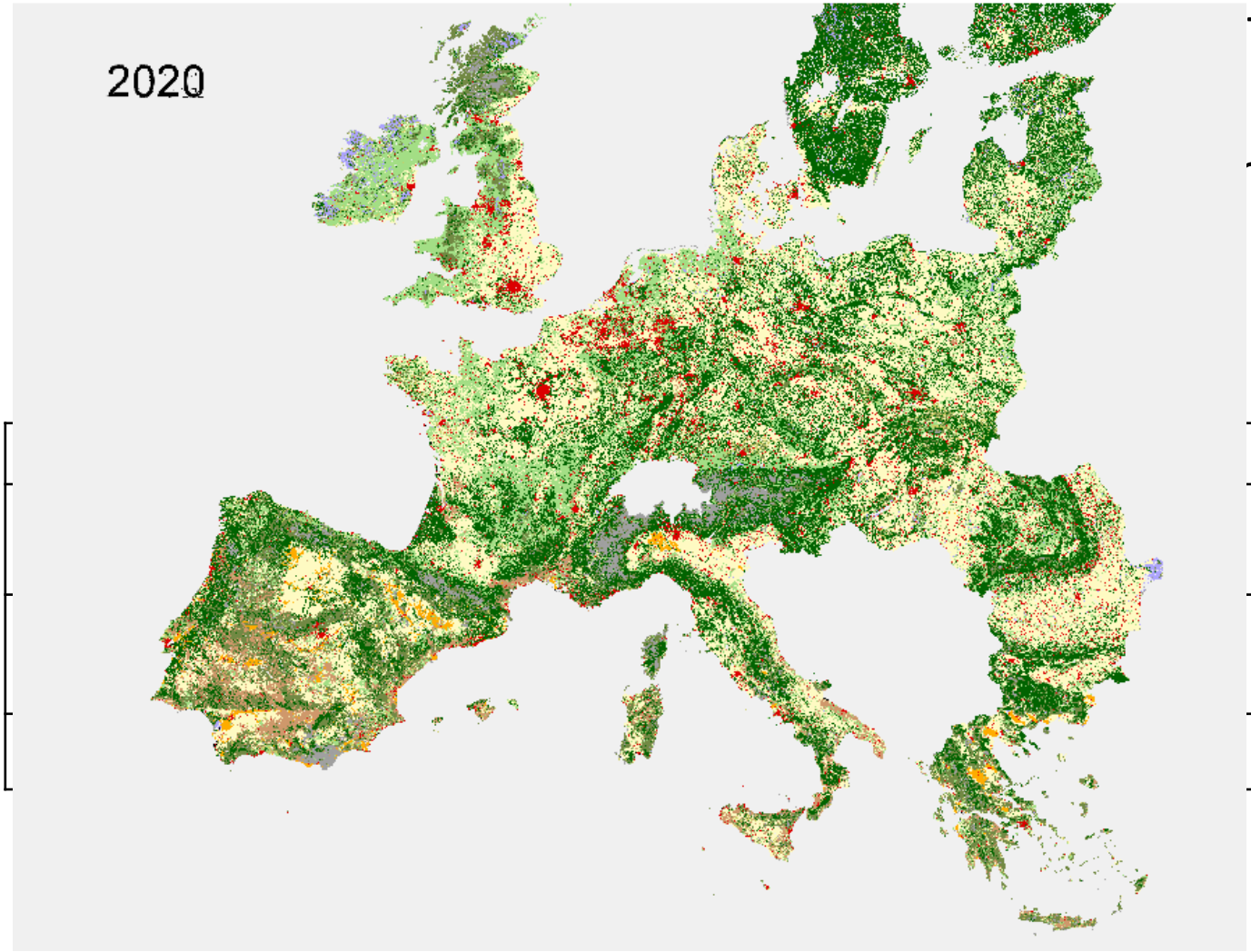
Axis 1:
Consumerism vs. Community
Reactive vs. Proactive

Axis 2:
Autonomy vs. Interdependence
Regionalized vs. Globalized

European

Project	Duration	Spatial coverage	Land use	No.
ATEAM	2001-2004	EU15, Norway, Switzerland	PELCOM	7
ACCELERATES	2001-2004	EU25 (Biodiversity change: EU27)	PELCOM	10 + 2
ALARM	2004-2009	EU25, Norway, Switzerland	PELCOM	6
PRELUDE	2007	EU 25, Norway, Switzerland	PELCOM	5
Scenar 2020	2005-2006	EU27	CORINE	3

Land use change scenarios and ecosystem services



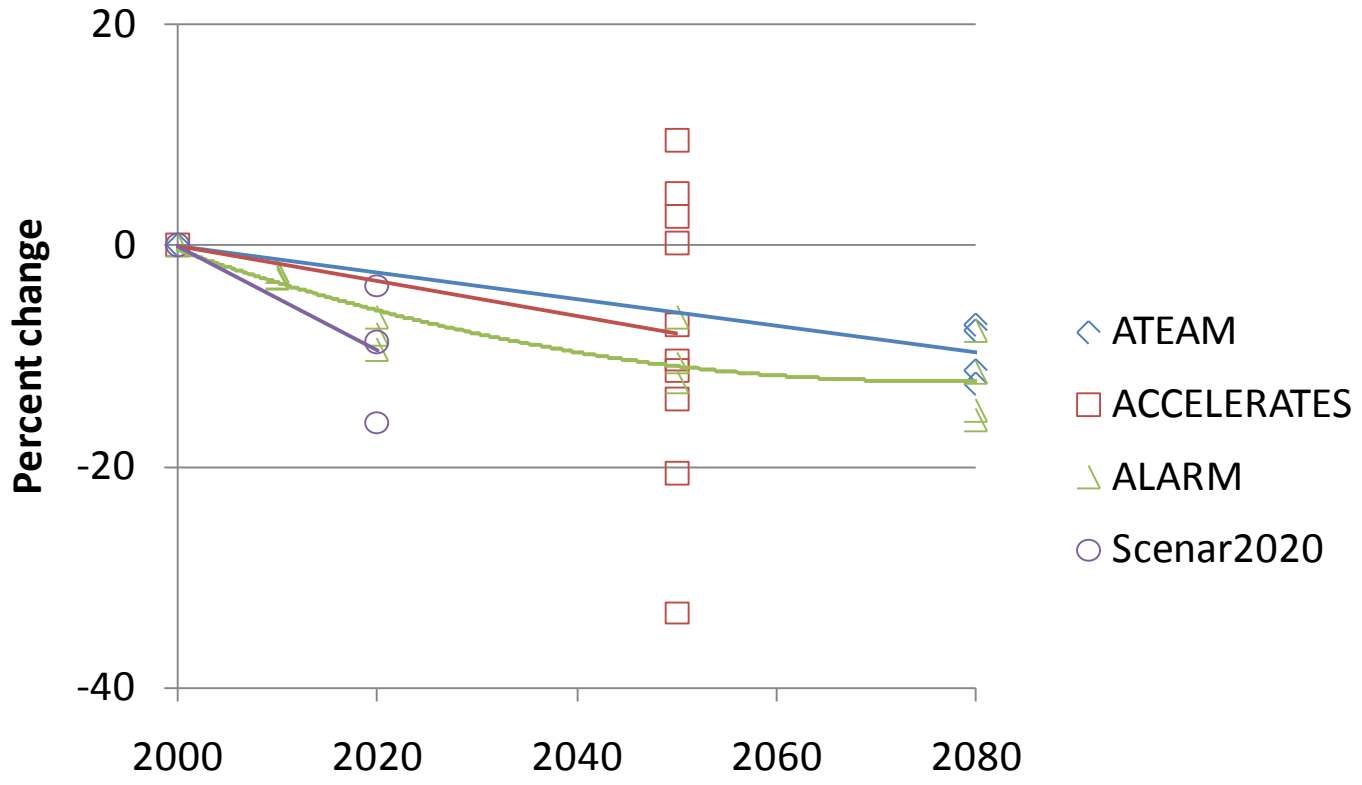
festyles etc.

n, ageing

	Scenar 2020
	LEITAP
	ESIM, CAPRI
	CLUE-s

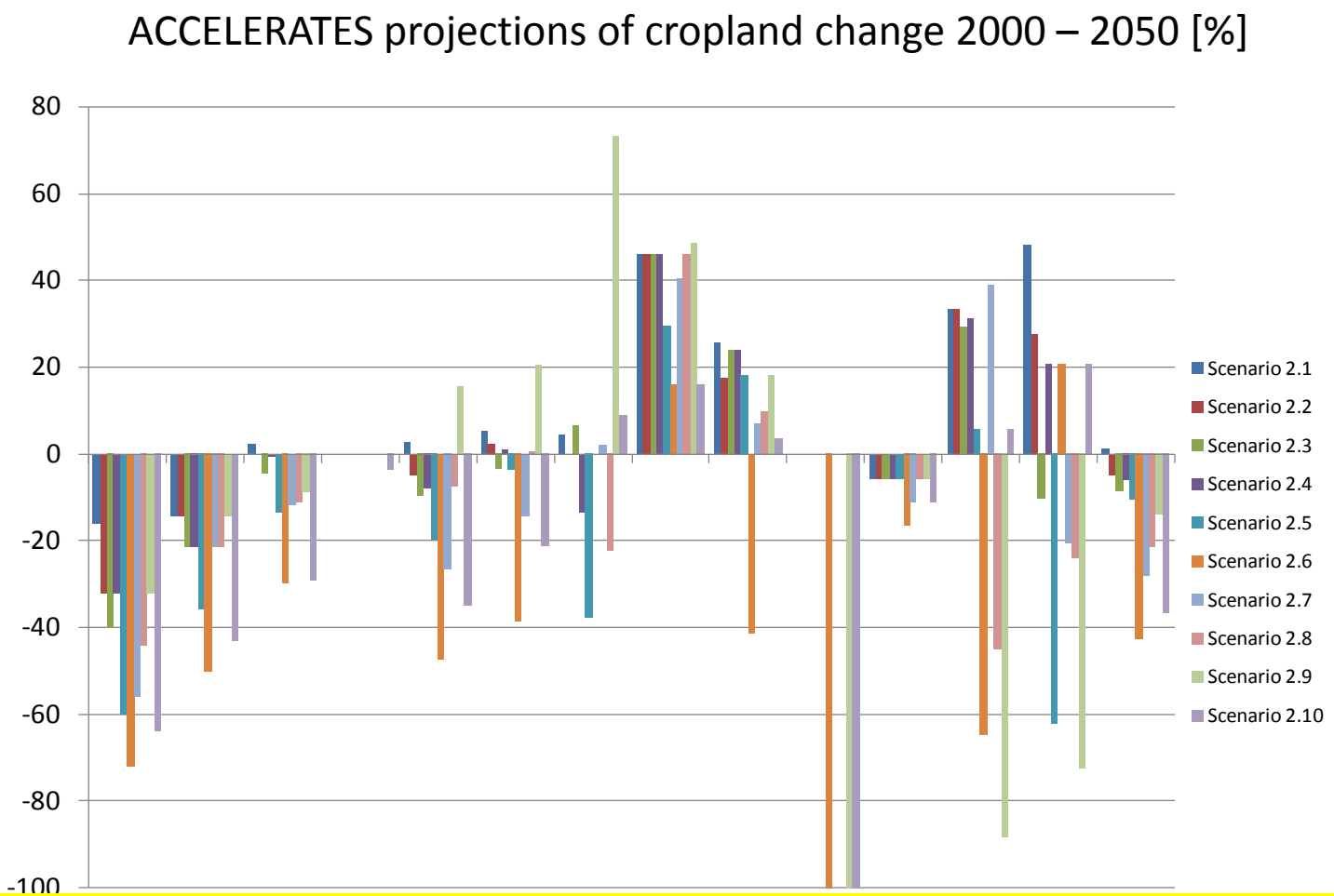
European land use change projections

Change in cropland area in the EU (15, 25, 27) [% compared to baseline in 2000]



- Average trends agree across scenario exercises
- But, how about spatial variability at smaller spatial scales?

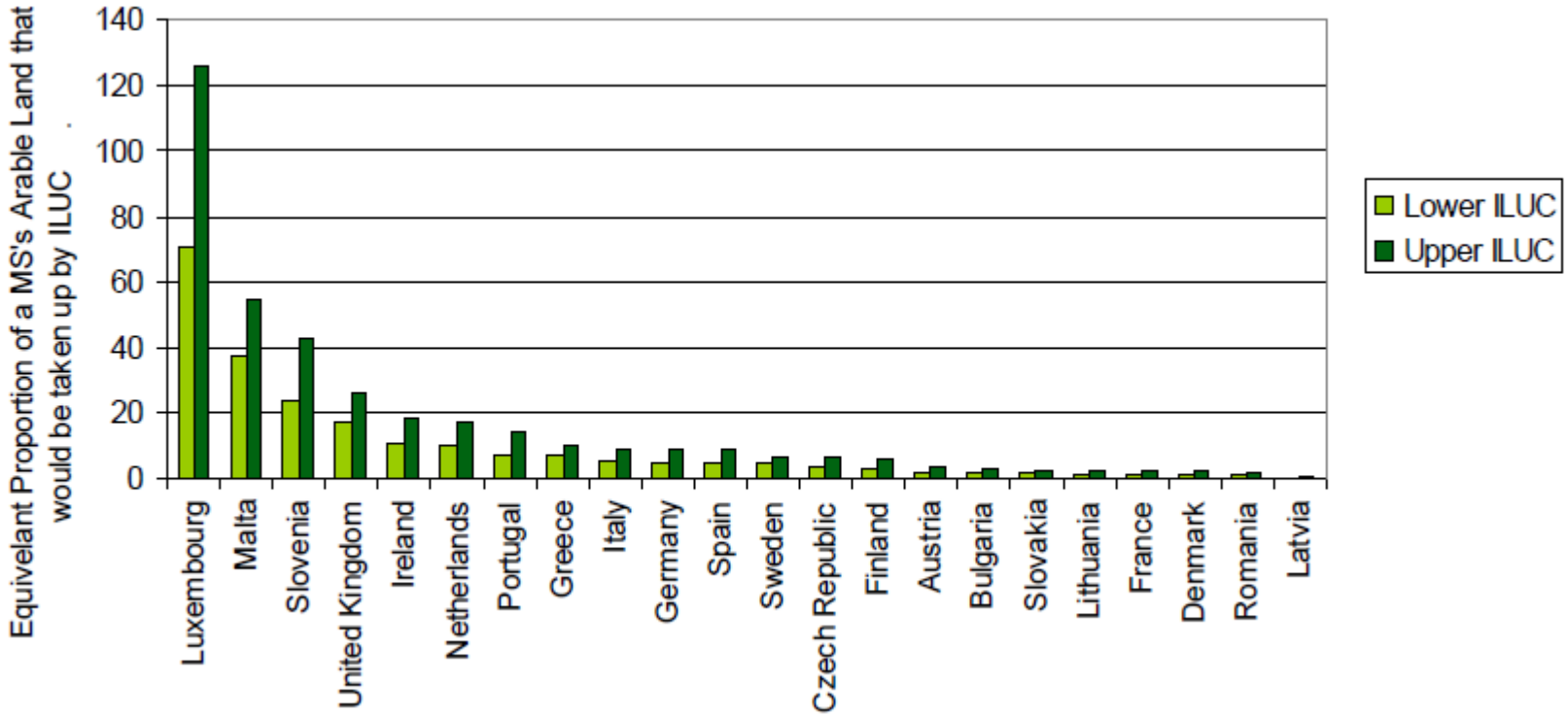
European land use change projections



- Very high variability among countries
- Some countries show opposite trends under different scenarios

European land use change projections

Estimated land use change effect of the implementation of the European Renewable Energy Directive



Source: IEEP 2010

Land use change scenarios and ecosystem services

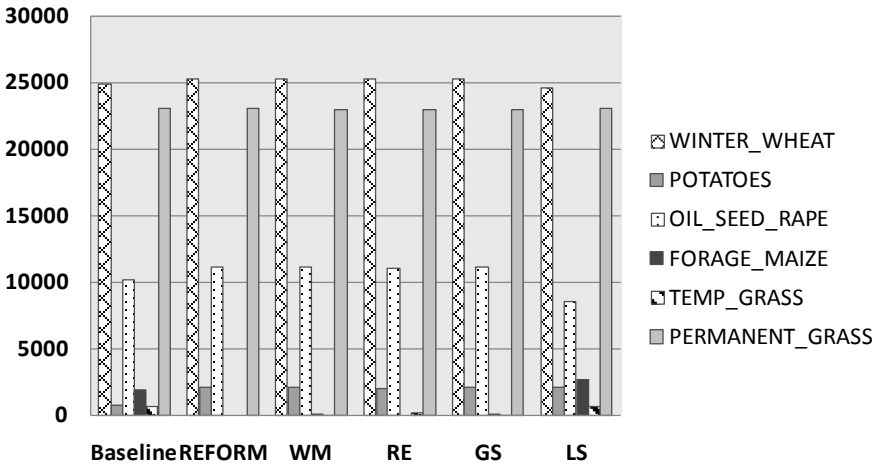
Projections of yields, total revenues and farmers‘ profits under four different ACCELERATES scenarios

No change in C	**2010**	**WM**	**RE**	**GS**	**LS**
Yield (kg/ha)	**7 593**	13 130	10 427	10 395	7 965
Total revenues (€/ha)	**990**	**1 277**	**1 202**	**1 400**	**1 207**
Farmers profit (€/ha)	**34**	**291**	**134**	**64**	**-142**

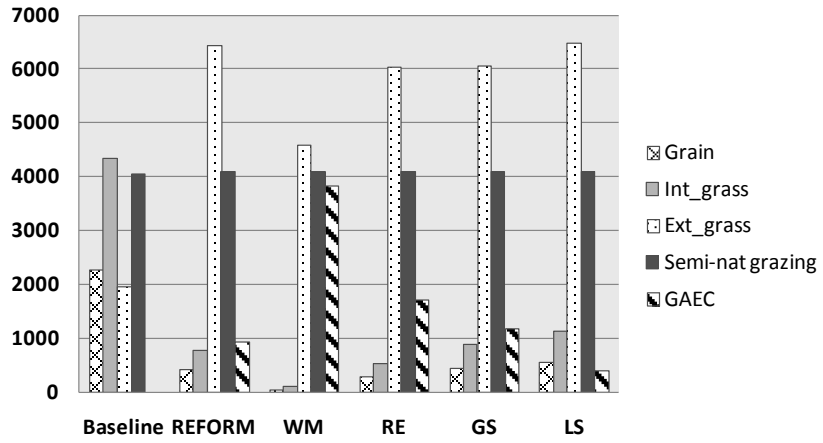
C change - 1%/yr		**WM**	**RE**	**GS**	**LS**
Yield (kg/ha)		12 325	9 788	9 758	7 477
Total revenues (€/ha)		**1 199**	**1 128**	**1 315**	**1 133**
Farmers profit (€/ha)		**213**	**60**	**-22**	**-216**

C change +1%/yr		**WM**	**RE**	**GS**	**LS**
Yield (kg/ha)		14 153	11 240	11 204	8 586
Total revenues (€/ha)		**1 377**	**1 295**	**1 510**	**1 301**
Farmers profit (€/ha)		**391**	**227**	**173**	**-48**

Scenarios and farmer‘s decisions: land use projections



Land use hardly changes in favourable farming areas



Land use in less favourable farming areas changes more strongly

European policies and soil

Valuation of provisioning and regulating services in the context of farmers' economy is (comparatively) straightforward

There is potential for applications in European policy contexts, e.g.:

- Common Agricultural Policy
  - Cross compliance – Good Agricultural and Environmental Condition
  - 1st / 2nd Pillar, agri-environmental schemes
- Industrial Emissions Directive
- Renewable Energy Directive
- Water Framework Directive
- Habitats Directive
- Soil Thematic Strategy
- EU Biodiversity Strategy
  - Target 2, restoration of degraded land
- Soil Framework Directive ?

Thank you for your attention!

SOILSERVICE partners:

UNIVERSITY OF HELSINKI

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

University of Reading

NIOO

WAGENINGEN UNIVERSITEIT
WAGENINGEN UR

BIOLOGY CENTRE

LUND UNIVERSITY

UNIVERSITY OF COPENHAGEN

LANCASTER UNIVERSITY

ARISTOTLE UNIVERSITY OF THESSALONIKI

SLI