

JRC EUROPEAN COMMISSION AAAS ADVANCING SCIENCE. SERVING SOCIETY


Chicago, 12-18 February 2009 - AAAS Annual Meeting

## Land use and Climate change:

### What do we need to know to protect soil biodiversity

**Volkmar Wolters**  
 Research Centre for BioSystems, Land use & Nutrition  
 Justus-Liebig-University Giessen, Germany

volkmar.wolters@uni-giessen.de

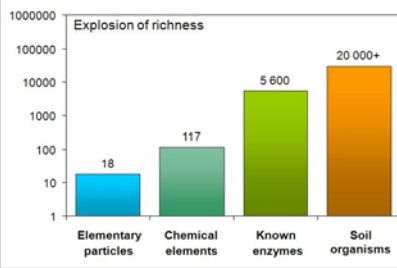


JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

## Land use and Climate change:

### What do we need to know to protect soil biodiversity



Category	Count
Elementary particles	18
Chemical elements	117
Known enzymes	5 600
Soil organisms	20 000+

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

## Land use and Climate change:

### What do we need to know to protect soil biodiversity




JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

## Land use and Climate change:

### What do we need to know to protect soil biodiversity



- Appropriate biodiversity (community structures) lead to an effective functioning of the system
- How do we achieve this in agricultural systems?

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

## Land use and Climate change:

### What do we need to know to protect soil biodiversity




Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

## Use soil biodiversity

### to protect land and cope with climate change



Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### New challenges to agriculture:

- Secure food supply to a rapidly growing human population
- Minimize the adverse impacts of agricultural production on the environment

Year	Population (billions)
1800	1
1920	2
1975	4
2005	6.5

Source: UN Population Division 2004; Lee, 2003; Population Reference Bureau; Millennium Ecosystem Assessment

Land use and climate change: what do we need know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### Hypothesis

Optimizing the use ecosystem services (ES) provided by soil biota allows for merging these issues  
...and also guarantees a high level of soil biodiversity

*"BIOLOGICAL ENGINE OF THE EARTH"*

Land use and climate change: what do we need know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### ES provided by soil biota:

- Control of pests and diseases
- Close circuits of nutrients and organic matter
- Improve soil conditions and water availability

Land use and climate change: what do we need know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### ES provided by soil biota: Disease control

Plant

Soil

Pathogen

PGPR

Source: Hase & Döhring (2008) (modified)

Biocontrol of soil pathogens by plant growth-promoting rhizobacteria (PGPR)

Land use and climate change: what do we need know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### ES provided by soil biota: Nutrients

N <sub>2</sub> -Fixation	Symbiosis	Associations	Free-living	Optimum amount for corn
Amounts fixed kg N ha <sup>-1</sup> y <sup>-1</sup>	50 - 400 Rhizobia (Legumes)	10 - 50	1 - 2	10 - 80
				120 kg N ha <sup>-1</sup> y <sup>-1</sup>

→ Increase above-ground diversity in arable fields

Source: Barrios 2007 (modified)

Land use and climate change: what do we need know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE. SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### Hypothetical Cause-Effect Chain

Increasing above-ground biodiversity

- Higher amount, diversity and quality of SOM
- Stimulation of soil biodiversity
- Changes in soil food webs
- Improvement of ES (e.g. nitrogen provision)
- Reduced adverse impacts on the environment

(i) less leaching, high nutrient use efficiency  
(ii) reduced use and leakage of pesticides  
(iii) diminishing the need for destructive tillage

Land use and climate change: what do we need know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE, SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### Hypothetical Cause-Effect Chain: we know a lot

Increasing above-ground biodiversity  
 → Higher amount, diversity and stability of SOM  
 → Stimulation of soil biodiversity

..., but we still need to learn how


- to systematically use it in agriculture
- achieve this at a maximum level of soil biodiversity
- it is modulated by regional conditions
- various ES interfere with each other

Land use and climate change: what do we need to know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE, SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### ES provided by soil biota



<http://www.kem.ekol.lu.se/soilservice/index.html>

Land use and climate change: what do we need to know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE, SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### Management, soil biodiversity and ES

#### Current state of knowledge

Property	Natural ecosystem	Sustainable agroecosystem	Conventional agroecosystem
productivity	medium	medium (possibly high)	high
species diversity	high	medium	low
functional diversity	high	medium-high	low
output stability	medium	high	low-medium
biomass accumulation	high	medium-high	low
nutrient recycling	closed	semi-closed	open
trophic relationships	complex	intermediate	simple
natural population regulation	high	medium-high	low
resilience	high	medium	low
sustainability	high	high	low

→ Many 'medium-level' effects

Source: Gleeson 2005, Potts 2008 (modified)

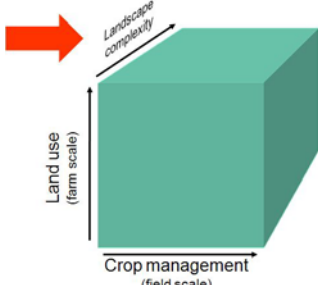
Land use and climate change: what do we need to know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE, SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### Management, soil biodiversity and ES

#### We must include additional dimensions



Source: Fitzhugh et al 2008 (strongly modified)

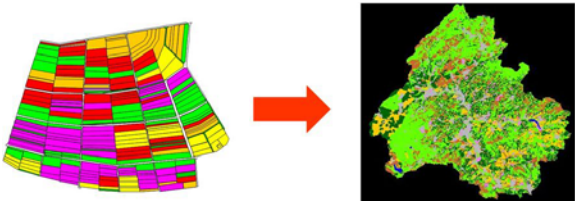
Land use and climate change: what do we need to know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE, SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### Managing at the landscape level

Enormous potential for optimizing the use ES at a high level of soil biodiversity



Landscape matrix integrating a variety of management types

Land use and climate change: what do we need to know to protect soil biodiversity? Volkmar Wolters

JRC EUROPEAN COMMISSION JUSTUS-LIEBIG-UNIVERSITY GIESSEN AAAS ADVANCING SCIENCE, SERVING SOCIETY

Chicago, 12-18 February 2009 - AAAS Annual Meeting

### Land use and Climate change:

#### What do we need to know to protect soil biodiversity

- relying on services provided by soil biodiversity increases sustainability
- a high level of soil biodiversity increases resistance against environmental change
- optimizing management at the landscape scale allows for a rapid adjustment to changing conditions

Land use and climate change: what do we need to know to protect soil biodiversity? Volkmar Wolters

## Land use and Climate change:

What do we need to **know** to protect soil biodiversity

- Use of available data
- Large-scale, long-term field experiments
- Applying new analytical tools

Learn how to protect soil biodiversity via complementing alpha-, beta- and gamma-diversity by alpha-, beta- and gamma-knowledge