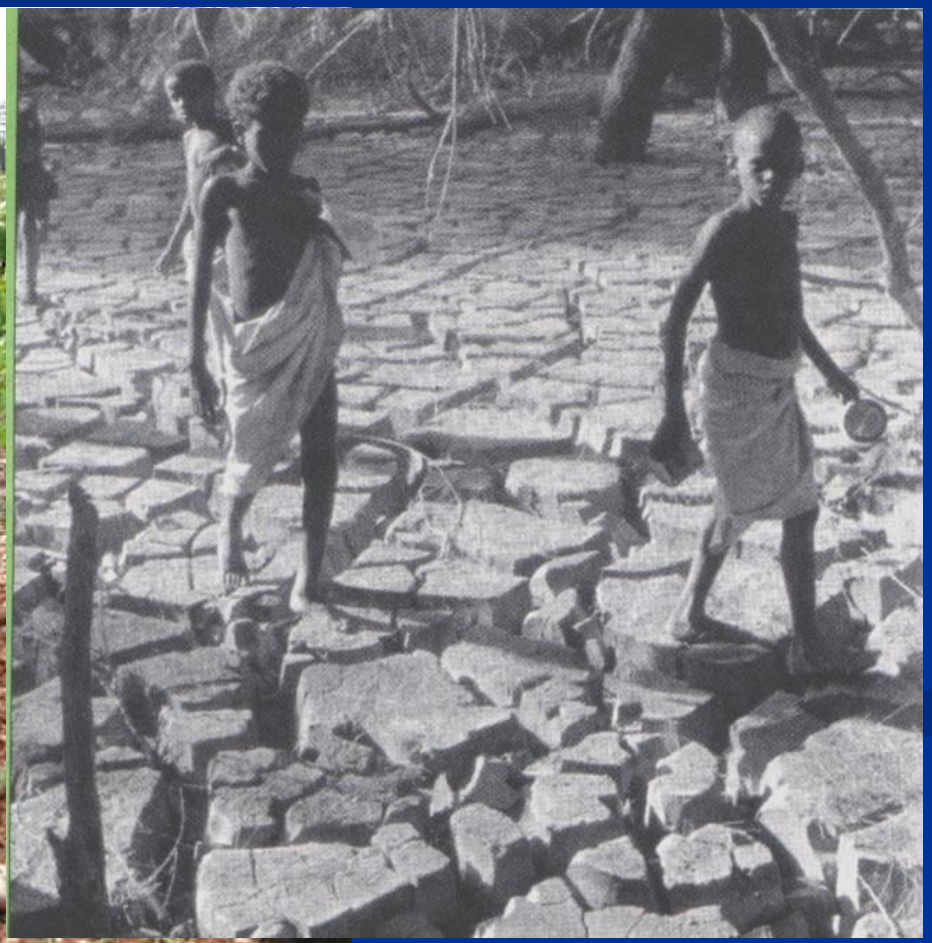
Dipartimento Scienze Agrarie e Ambientali –
Università degli Studi di Udine

Nevarnosti degradacije tal

I fattori di degradazione del suolo

Marco Contin

Soil is defined as the top layer of the earth's crust situated between the bedrock and the surface, excluding groundwater.



Soil has multiple functions

1. Biomass production, including agriculture and forestry;
2. Storing, filtering and transforming nutrients, substances and water;
3. Biodiversity pool, such as habitats, species and genes;
4. Physical and cultural environment for humans and human activities;
5. Source of raw materials;
6. Acting as carbon pool;
7. Archive of geological and archeological heritage.

Soils are natural resources …..

- Little regulated
- Little monitored
- Usually private land
- Lack of public awareness on soil degradation
- Strictly linked to the planning of territory
- Not renewable

Soil is a not renewable natural resource

A **non-renewable resource** is a natural resource which cannot be produced, grown, generated, or used on a scale which can sustain its consumption rate, once depleted there is no more available for future needs. Also considered non-renewable are resources that are consumed much faster than nature can create them.

Temporal concept:

- The development of few centimeters of soil need hundreds or thousands of years

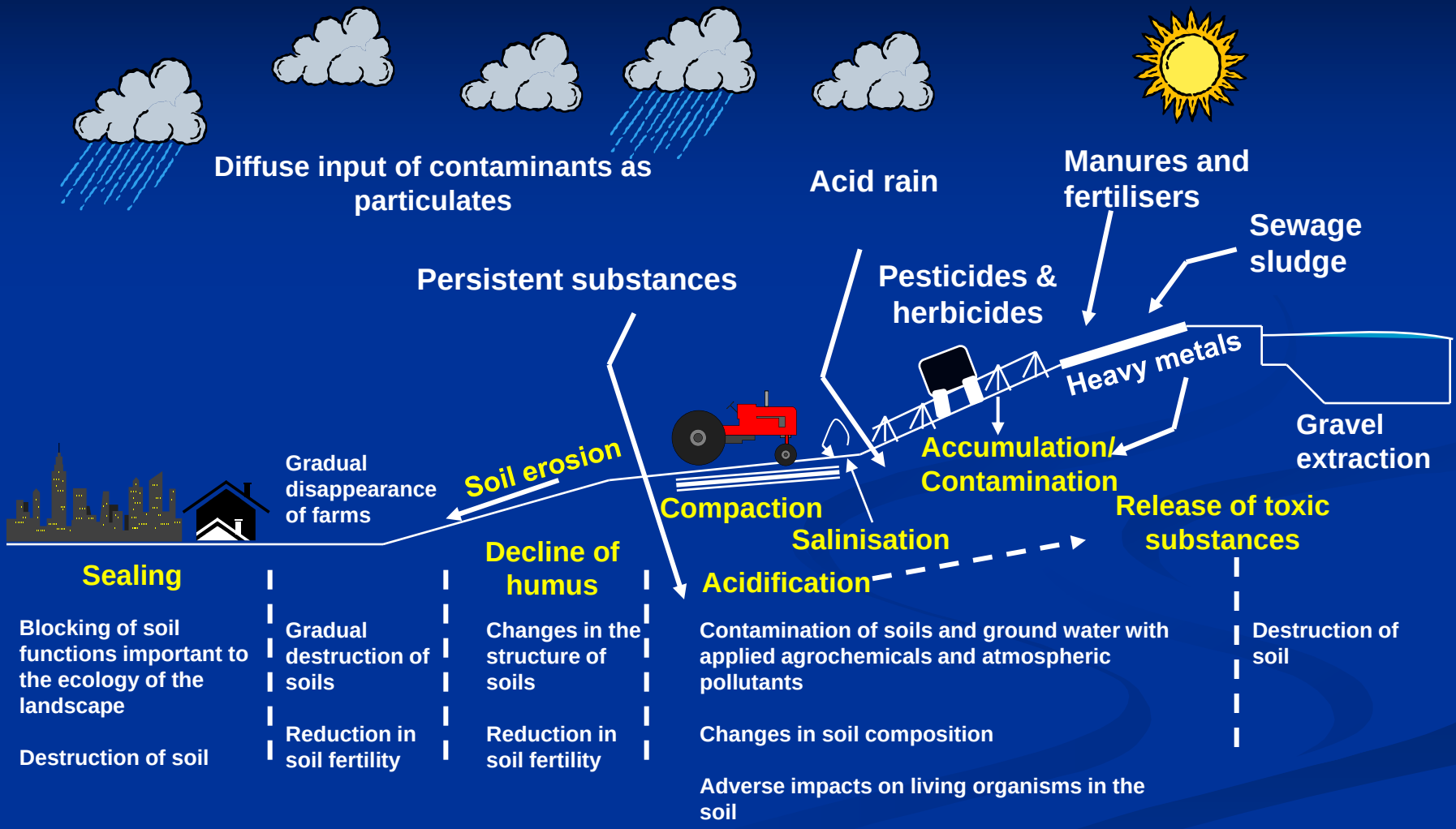
Concept of limitation of resources:

- Soils are limited

Several are the soil threats:

1. Erosion
2. Organic matter decline
3. Contamination
4. Soil Sealing
5. Compaction
6. Decline in soil biodiversity
7. Salinisation
8. Floods and Landslides

The impact of human activities on soil



Annual cost of soil degradation

Though difficult to estimate, several studies demonstrate significant *annual* costs of soil degradation to society in the ranges of:

- erosion: €0.7 – 14.0 billion,
- organic matter decline: €3.4 – 5.6 billion,
- compaction: no estimate possible,
- salinisation: €158 – 321 million,
- landslides: up to €1.2 billion per event,
- contamination: €0.6 – 17.3 billion,
- sealing: no estimate possible,
- biodiversity decline: no estimate possible.

1. Erosion

Loss of solid soil particles

Agents: - water
- wind

Causes: - topography
- strength of agents
- weakness of bounds between particles

1. Erosion

1 mm of soil correspond to: ~13 t/ha of soil

	Element Kg ha^{-1}	Efficiency %	N-P_2O_5-K_2O kg	Cost €/kg	Total cost €
C	260				???
N	30	35	85	0.80	68
P	3	20	40	0.65	26
K	5	40	15	0.60	9

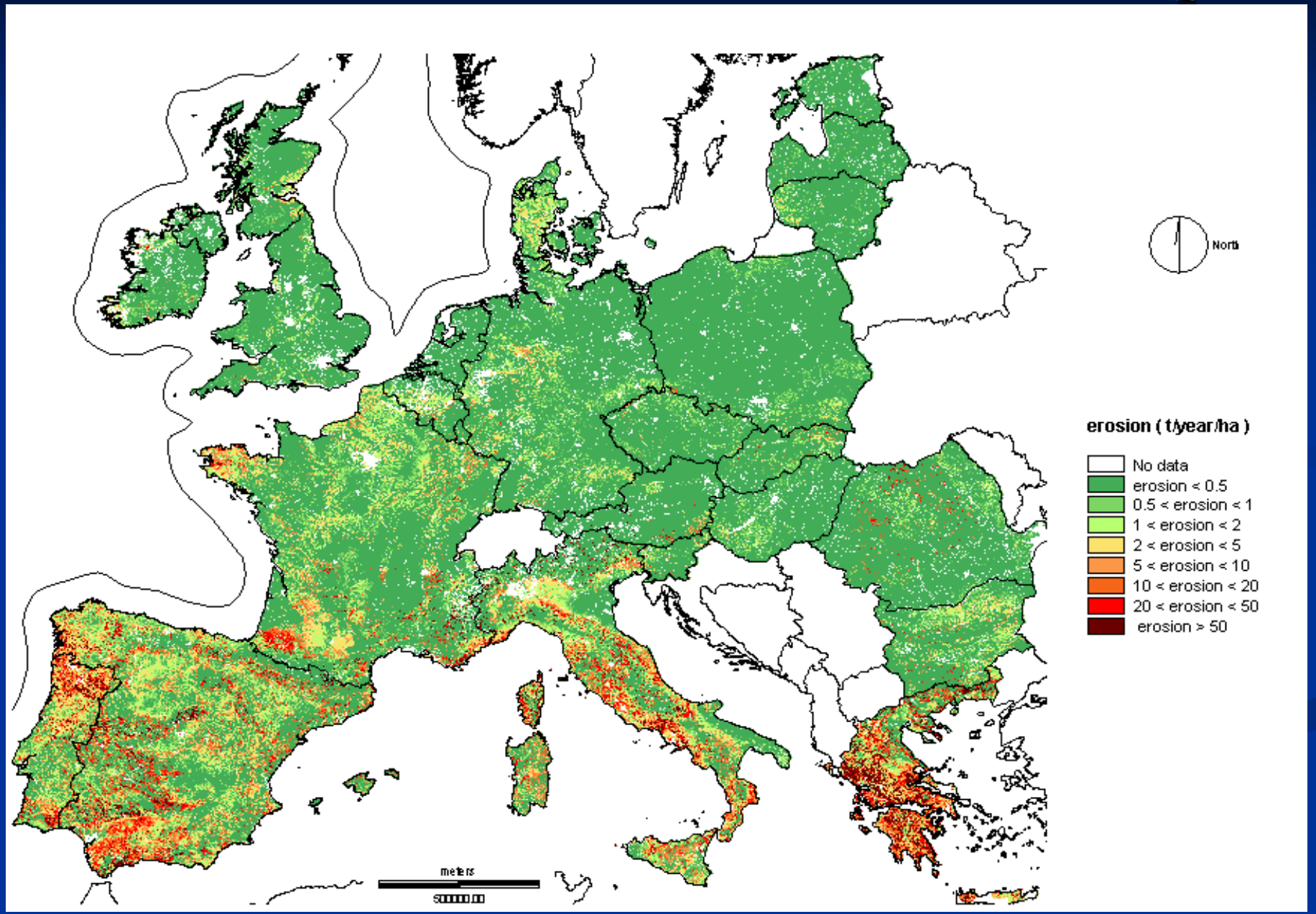
Total €/ha 103

1. Erosion

Rate of soil formation: 0.04 – 0.4 mm/y

2.5 - 25 years are required to develop 1 mm soil !!

Soil Erosion Risk Assessment in Europe



2. Soil organic matter decline

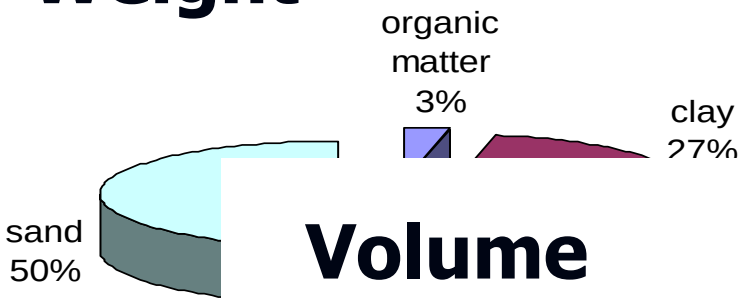
Decline of the concentration and quantity of organic matter

Agent: microbial respiration

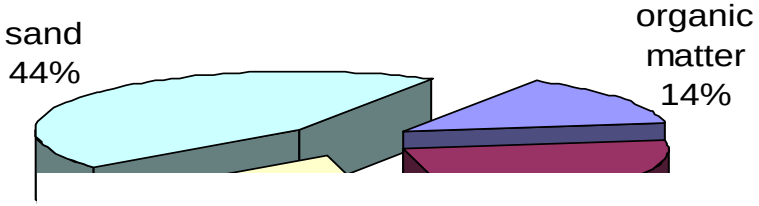
Products: CO_2 and other mineral elements

Importance of organic matter in soils

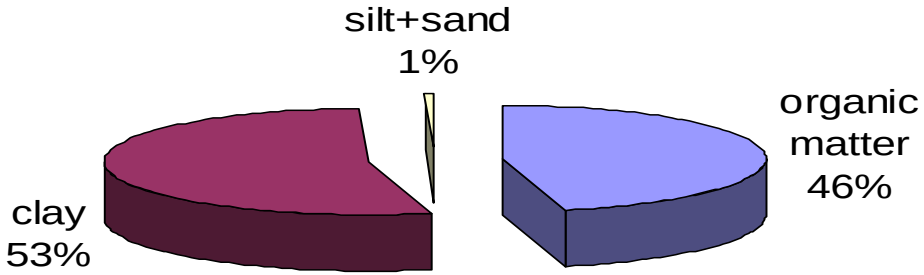
Weight



Volume



Surface

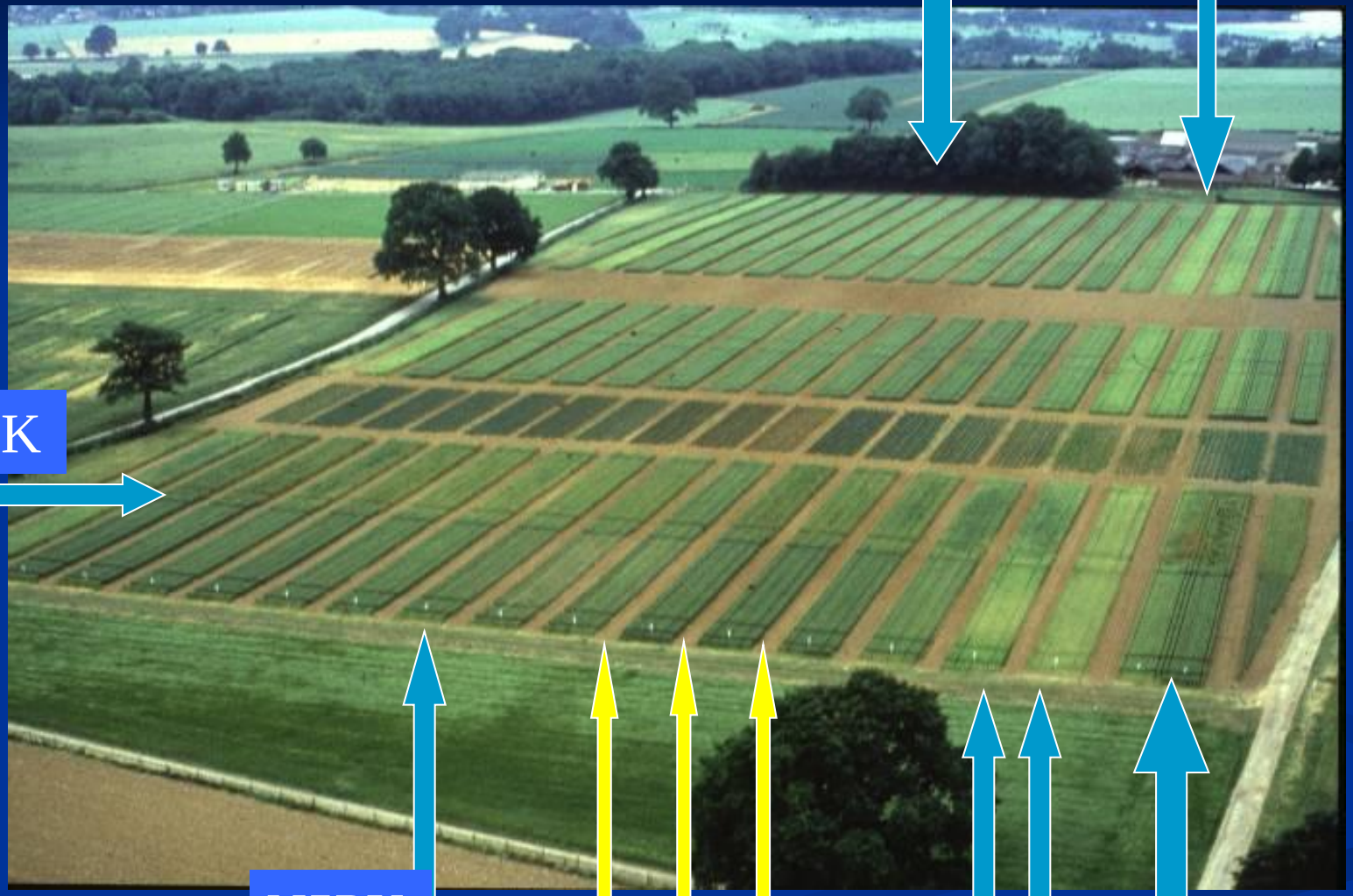


Consequences of soil organic matter decline

- Decrease of porosity
- Decrease of water retention
- Decrease of water infiltration
- Decrease of soil fertility (plant nutrition)
- Decrease of microbial biomass
- Decrease of the natural detoxification
- Increase of energy necessary for soil tillage
- Mobilization of inorganic contaminants
- Desertification
- Increase of CO_2 in the atmosphere

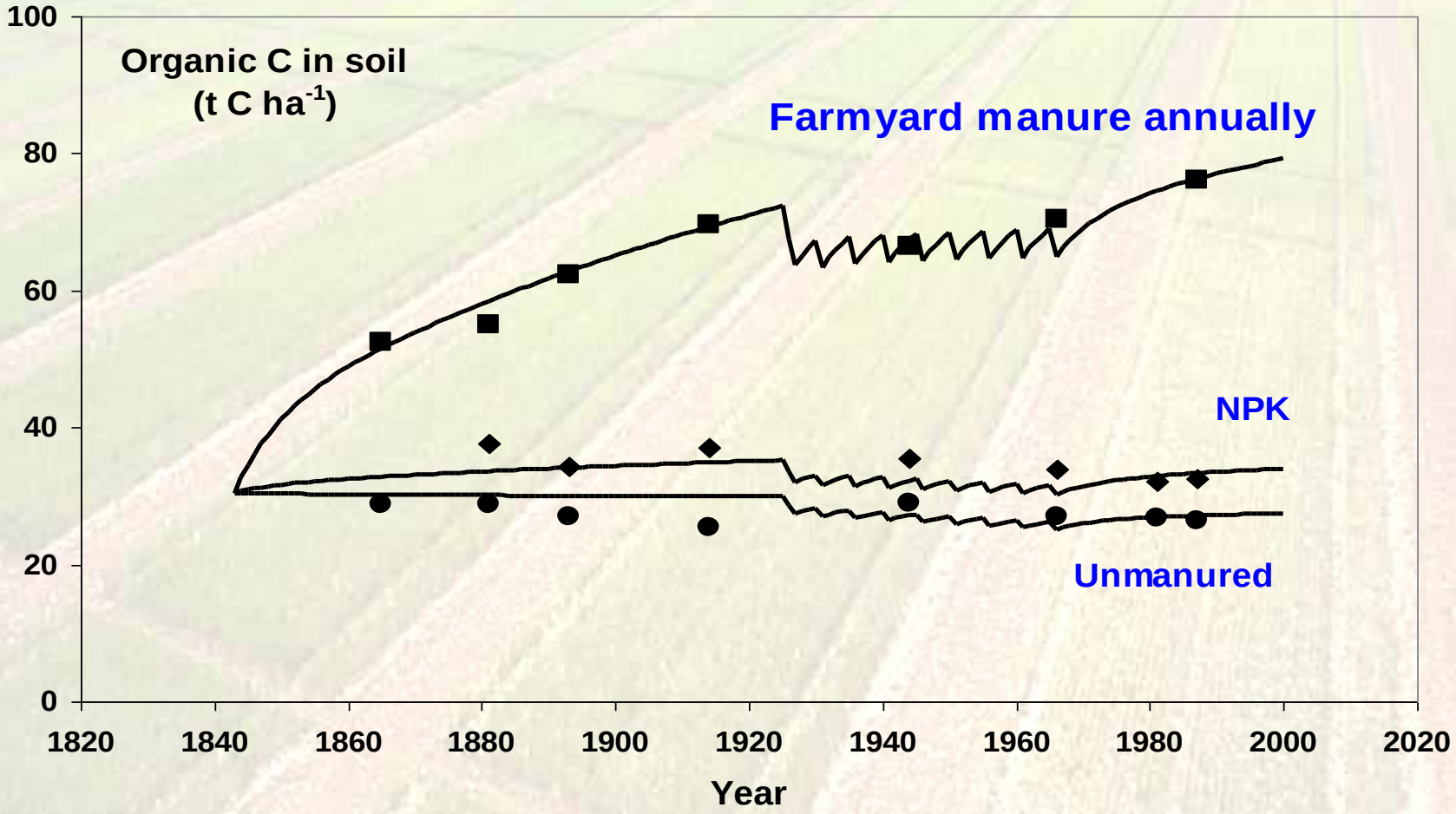
SOM and soil tillage

Rothamsted (UK)
Broadbalk, established in 1843

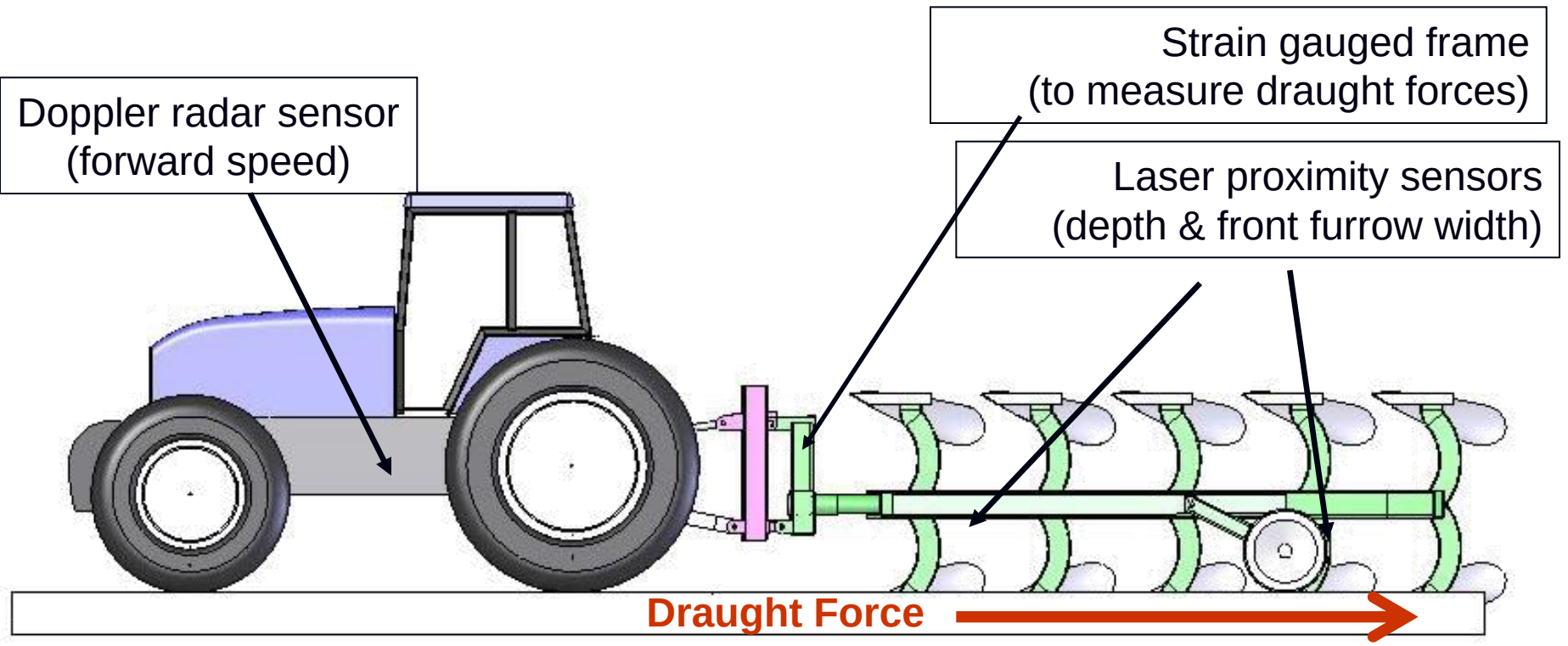


Broadbalk continuous wheat experiment

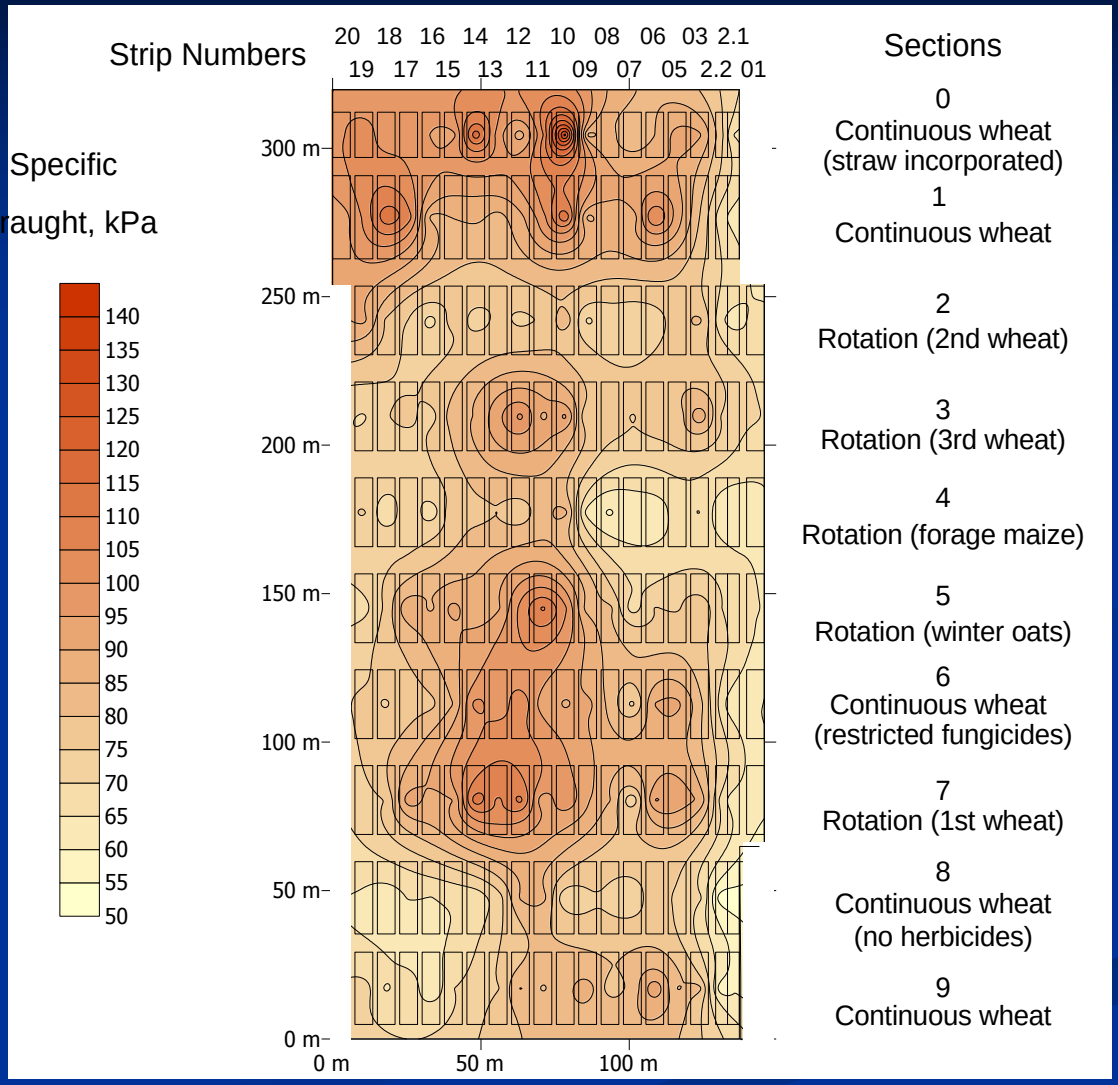
Data modelled by RothC-26.3 (solid lines)



Traction strength for soil tillage



Specific draught measurements; Broadbalk Experiment, Rothamsted



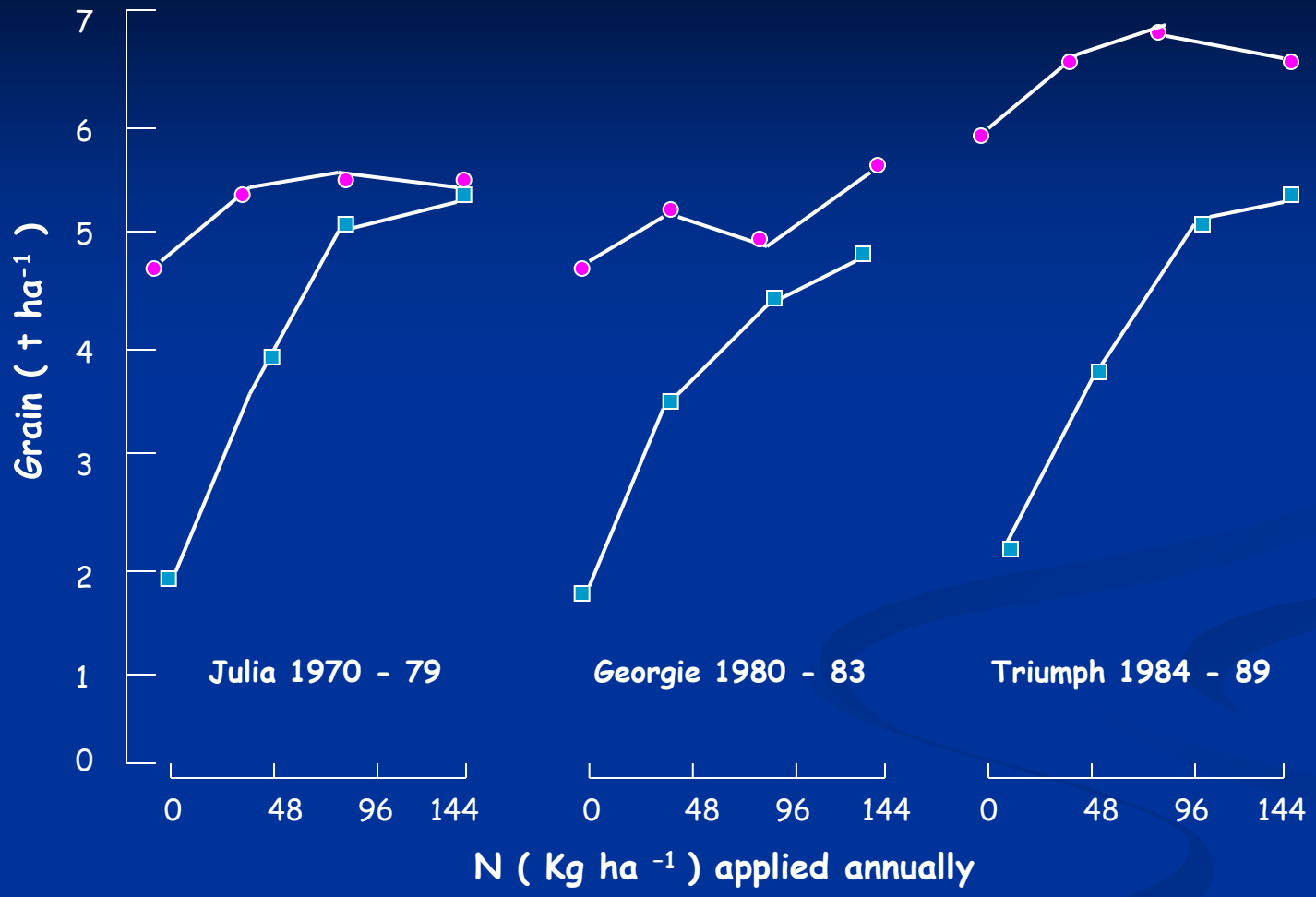
Watts, Clark, Poulton, Powlson, Whitmore.
Soil Use and Management **22**,*334-341* (2006)

SOM and tillage strength

fertilization	SOM %	Tract. strength kPa*
NIL	0.84	88
NPK	1.08	77
FYM	2.80	75

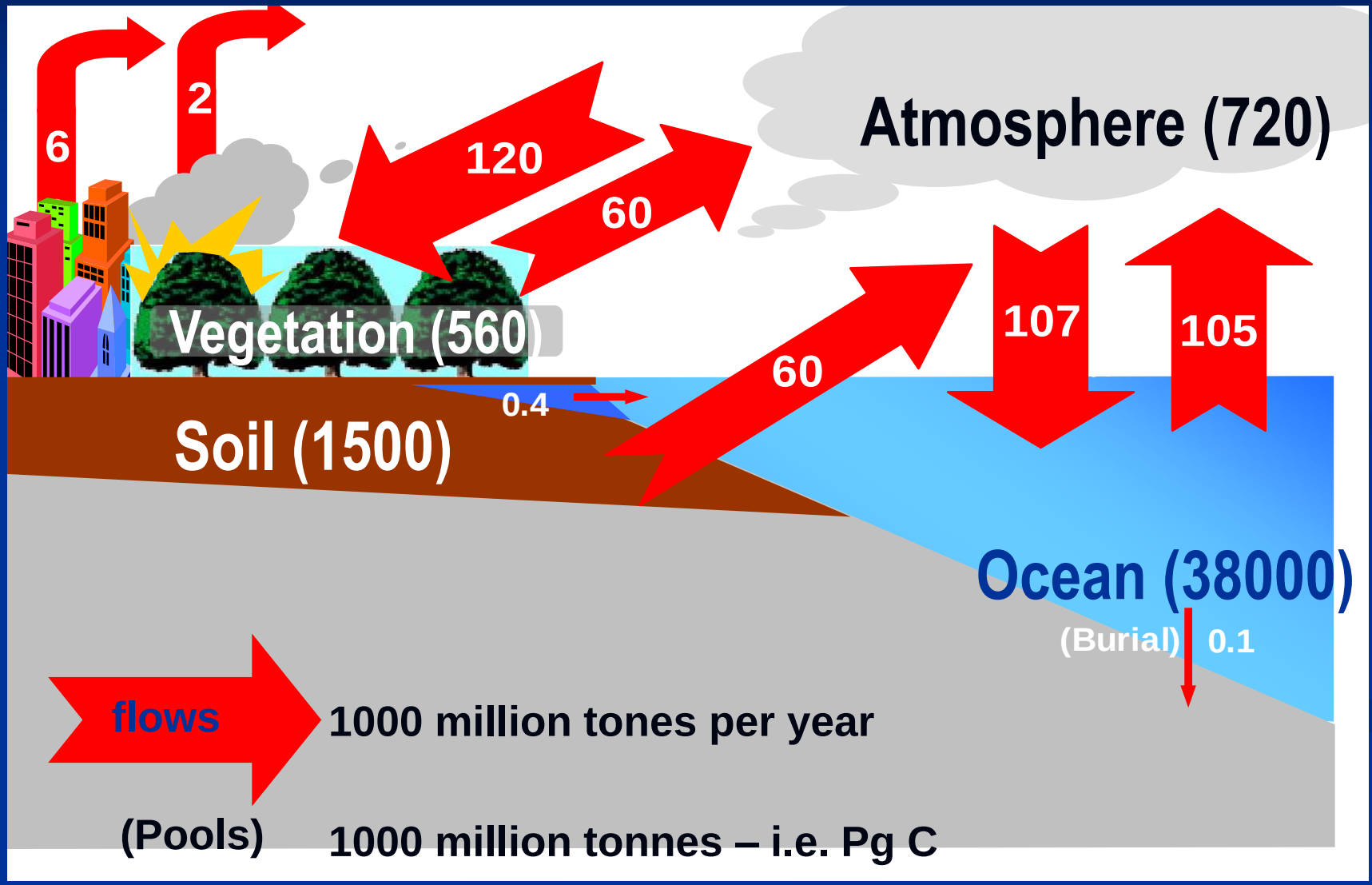
Watts et al (2006) *Soil Use and Management* **22**,*334-341* (2006)

The Rothamsted Classical Experiments

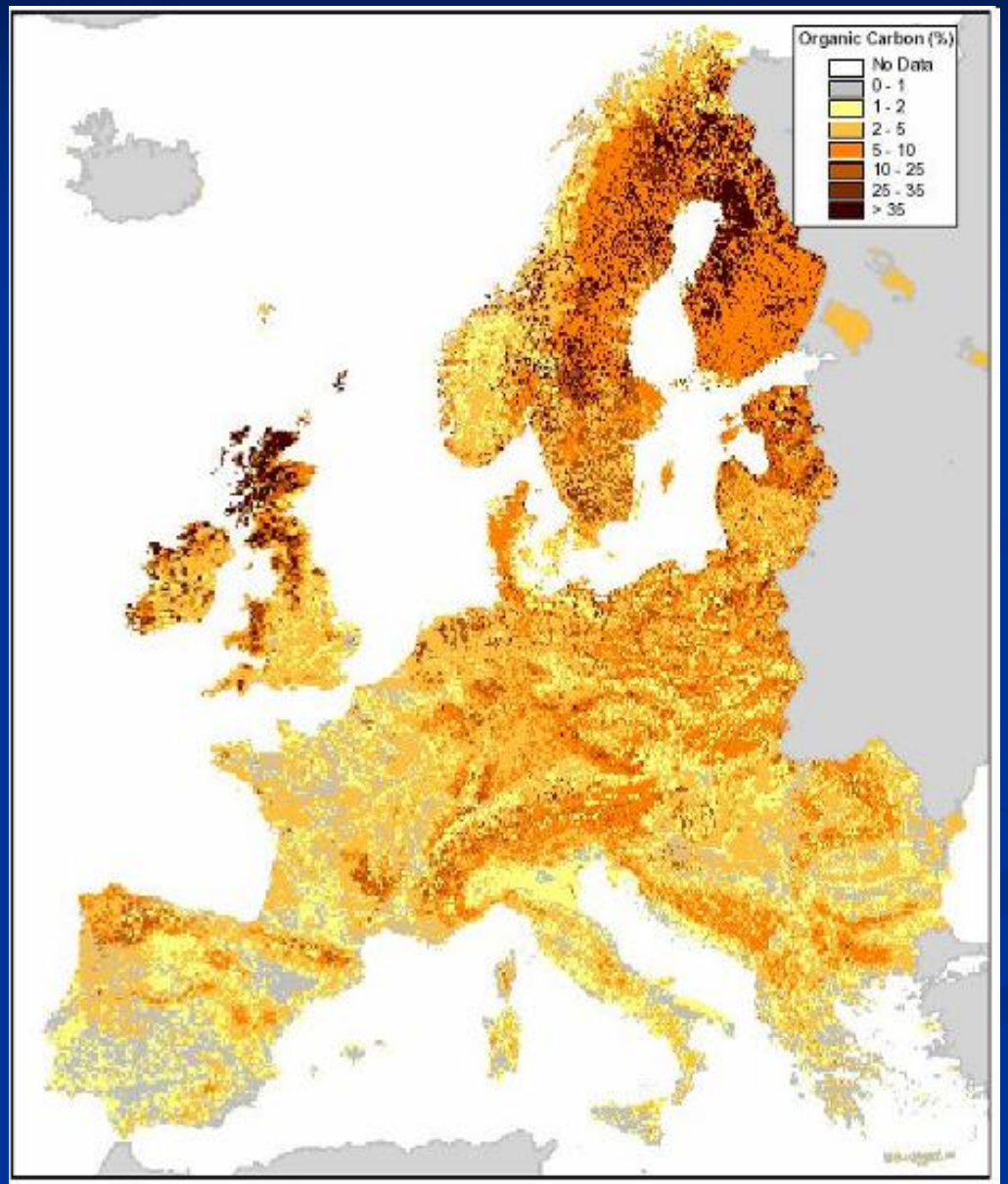


Yields of three cultivars of spring barley grows on soils with different amounts of soil organic matter, Hoosfield, Rothamsted. Soil given farmyard manure (●) since 1852 now contain 4.6% organic matter; those given PK fertilizers (■) now contain 1.8% organic matter.

Global carbon: stocks and flows



Soil Organic Carbon Stocks in Europe

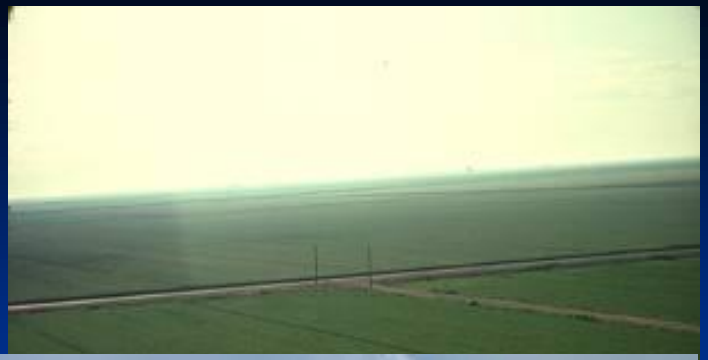


3. Soil Contamination

Accumulation of substances potentially toxic to humans, animals and or plants

Inorganic: PTE or … heavy metals radionuclides

Organic: organo-halogenated pesticides
pharmaceuticals
dioxins, PCB,
PolyAromatic hydrocarbons
……



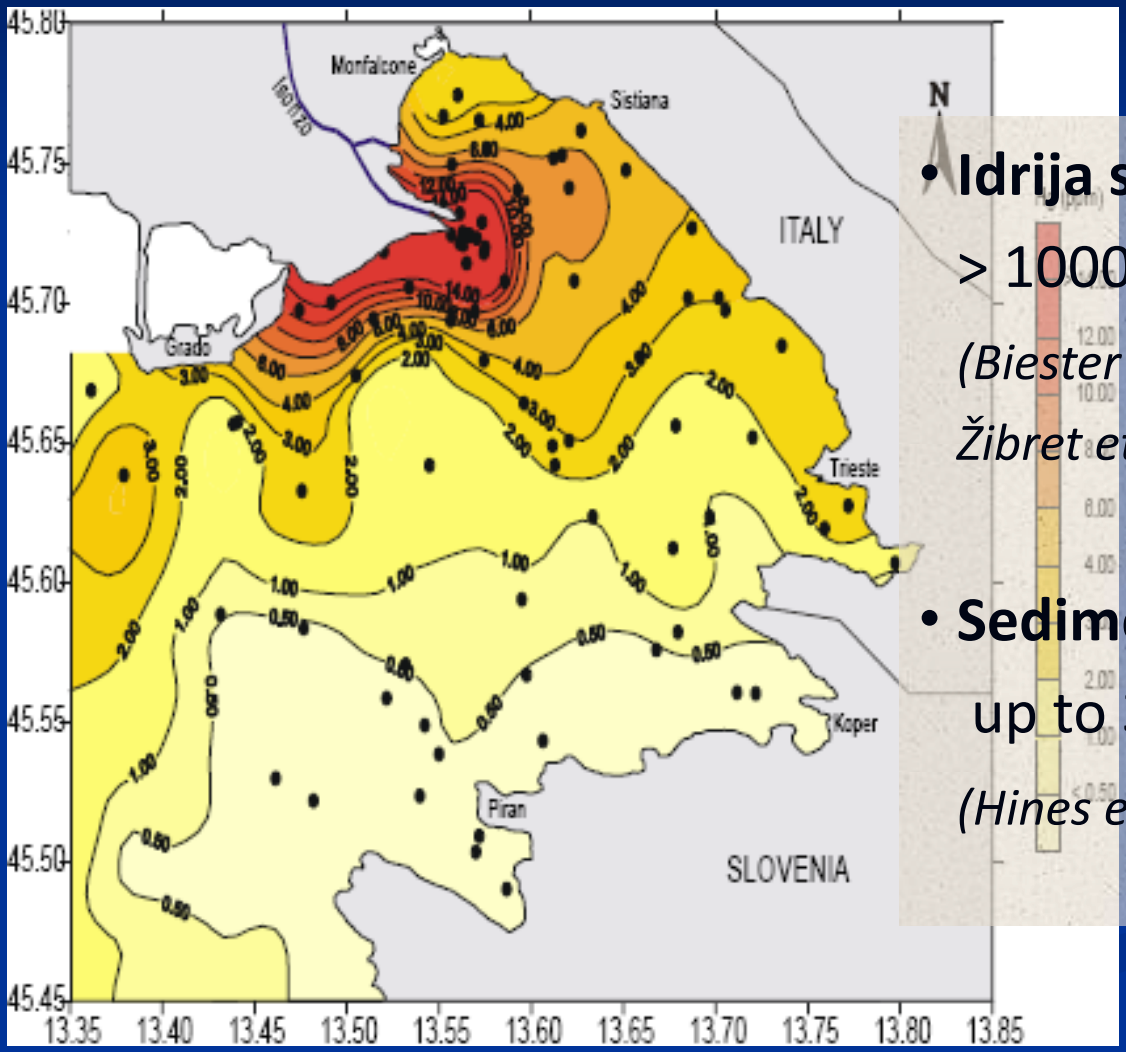
Historical Hg contamination in soils and sediments of Northern Adriatic Sea

- 500 years of activity (1490-1990)
- 127.000 t Hg ored
- > 37.000 t Hg dispersed in the environment
- ~ 1500 kg Hg per year in the Gulf of Trieste

Covelli et al. 2001

Soca-Isonzo river

Historical Hg contamination in soils and sediments of Northern Adriatic Sea



- **Idrija soils and Idrijca banks**

  > 1000 mg kg^{-1} of Hg

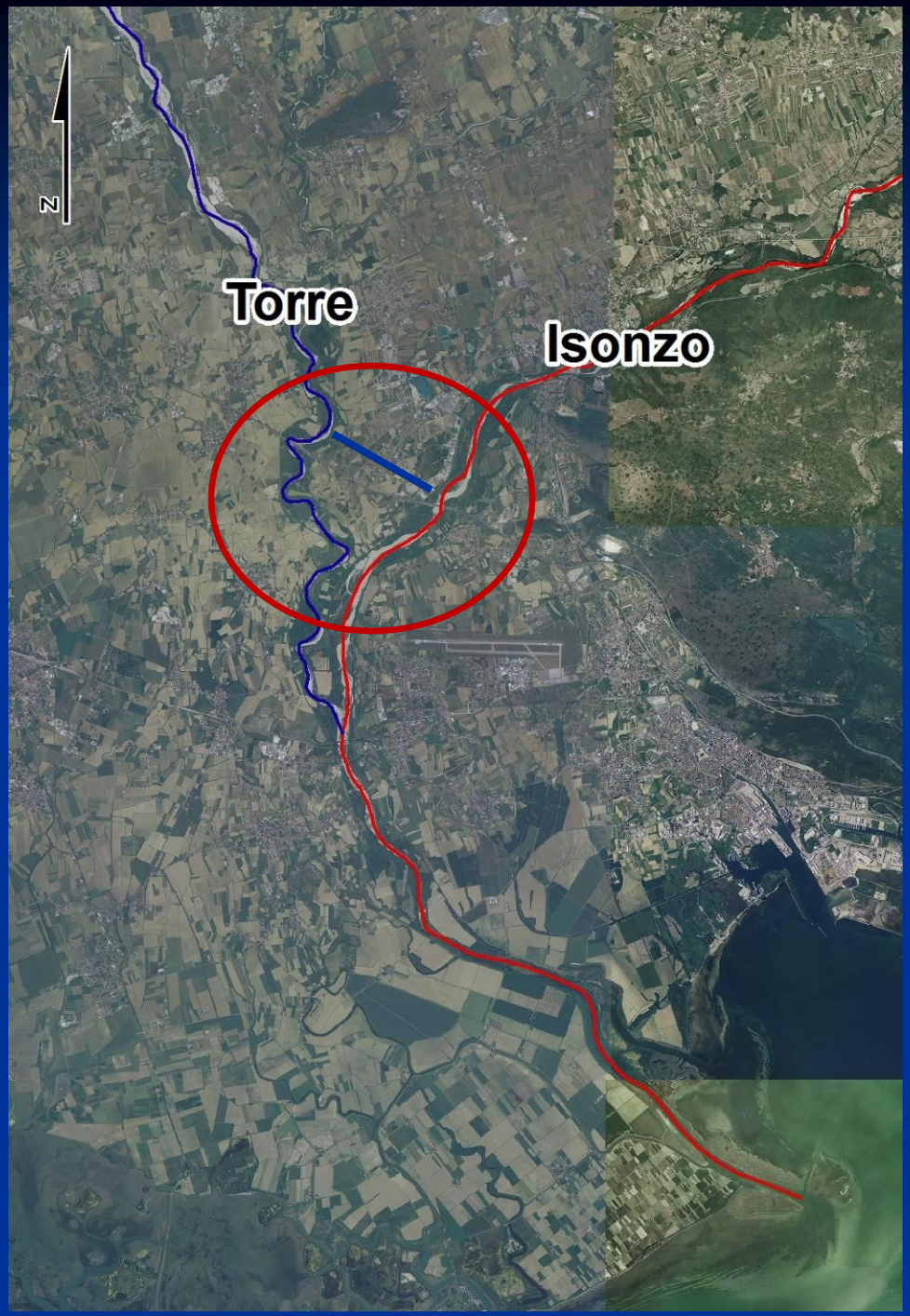
  (Biester et al. , 2000; Kotnik et al., 2005; Žibret et al., 2006)

- **Sediments in the gulf of Trieste**

  up to 30 mg kg^{-1}

  (Hines et al., 2000; Faganeli et al., 2003)

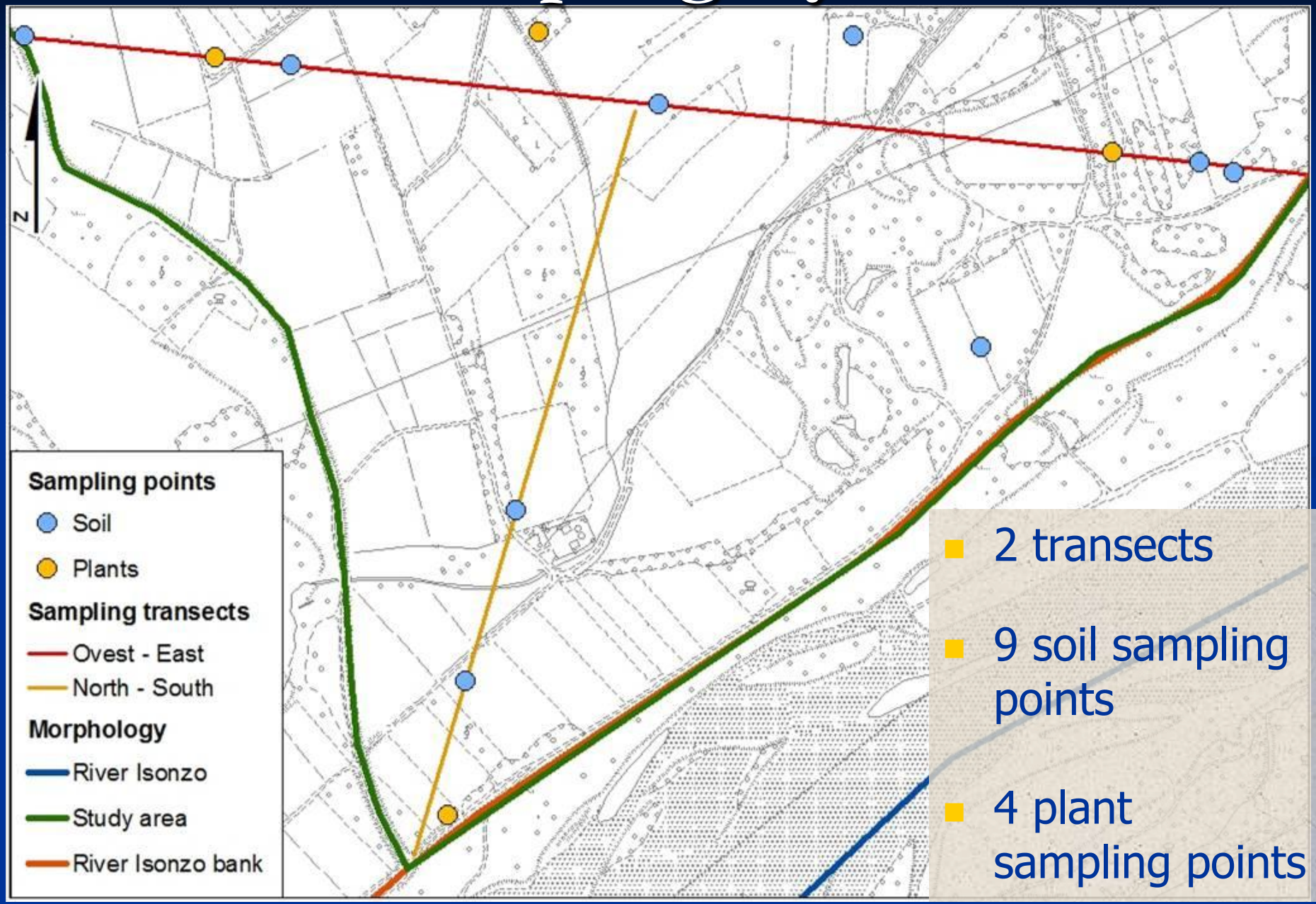
Covelli et al. 2001



Sampling field

- Flooded area between the banks of Isonzo and Torre rivers
- Historically flooded area
- Medium hydrographic hazard
- 10 important floods in last century

Sampling layout



- 2 transects
- 9 soil sampling points
- 4 plant sampling points

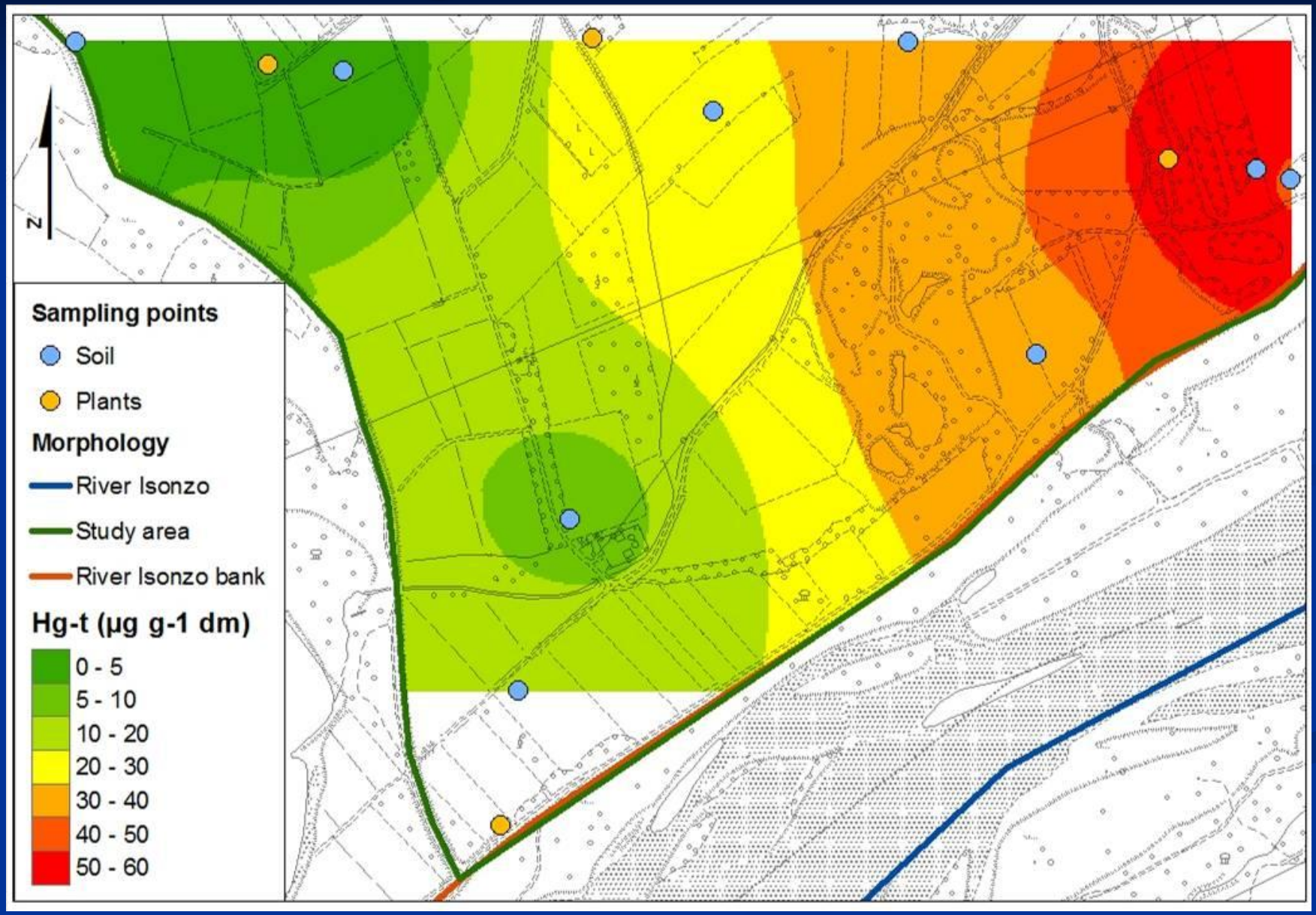
Total Hg in soils

Measured by acqua regia extraction as proposed by Bloom et al. (2003) and modified by Shi et al. (2005).

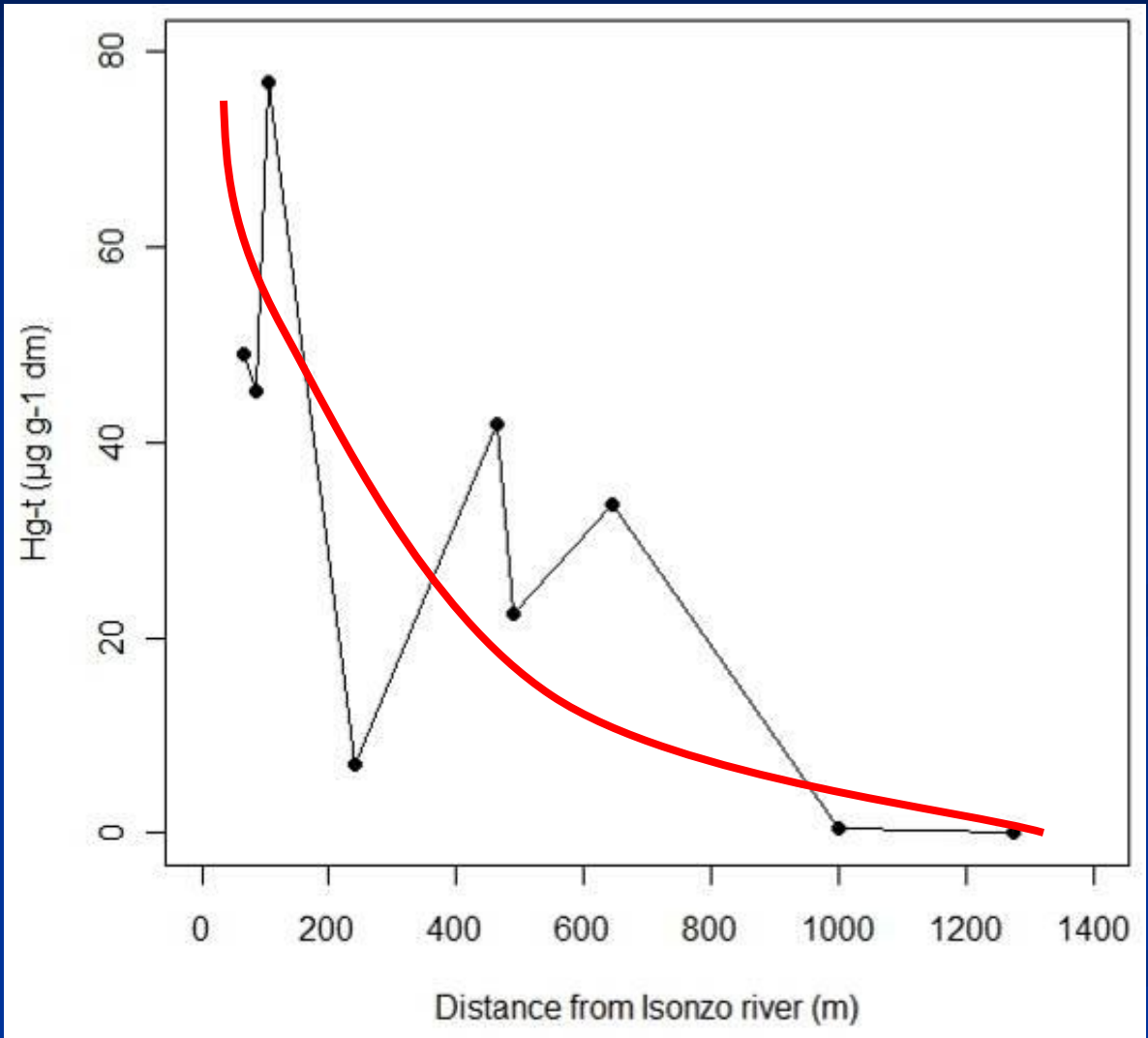
River Isonzo distance (m)	Total Hg (μg g^{-1})
65	49.07
85	45.29
105	76.88
240	6.97
465	41.90
490	22.51
645	33.56
1000	0.55
1275	0.16
Average	**30.76**

Threshold limits	Total Hg (μg g^{-1})
Residential area	**1.00**
Industrial area	**5.00**

Hg distribution



Total Hg in soils and river distance



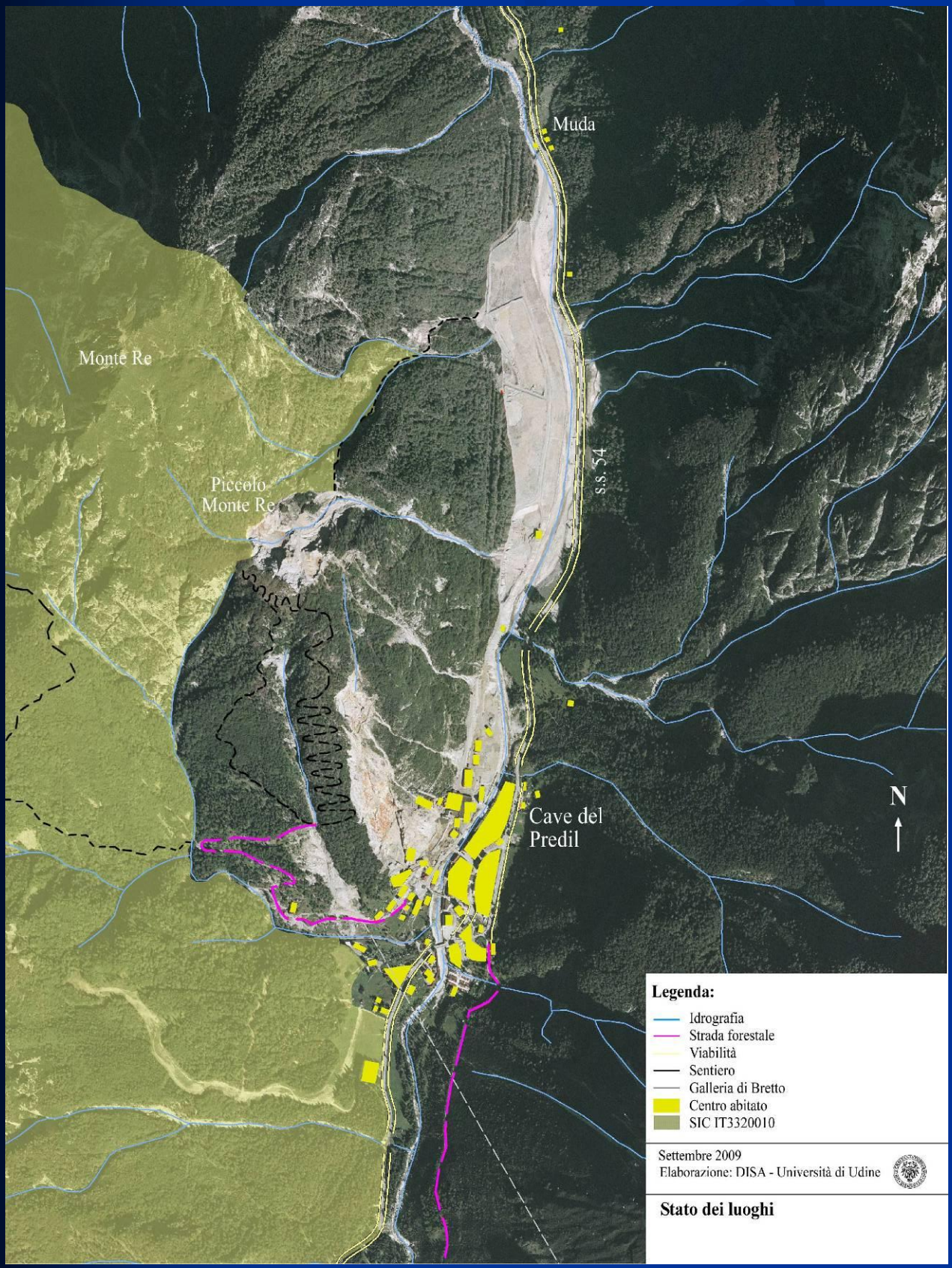
PTE contamination by Mine tailings in Raibl mine site

Mining Spharelite and Galena since 1000 b.c.

Pb and Zn

Mining activity was dismissed in 2001

2 million m^3 of tailings accumulated
130.000 m^2 area


Muda
Monte Re
Piccolo
Monte Re
s.s. 54
Cave del
Predil
N
Legenda:
Idrografia
Strada forestale
Viabilità
Sentiero
Galleria di Bretto
Centro abitato
SIC IT3320010
Settembre 2009
Elaborazione: DISA - Università di Udine
Stato dei luoghi

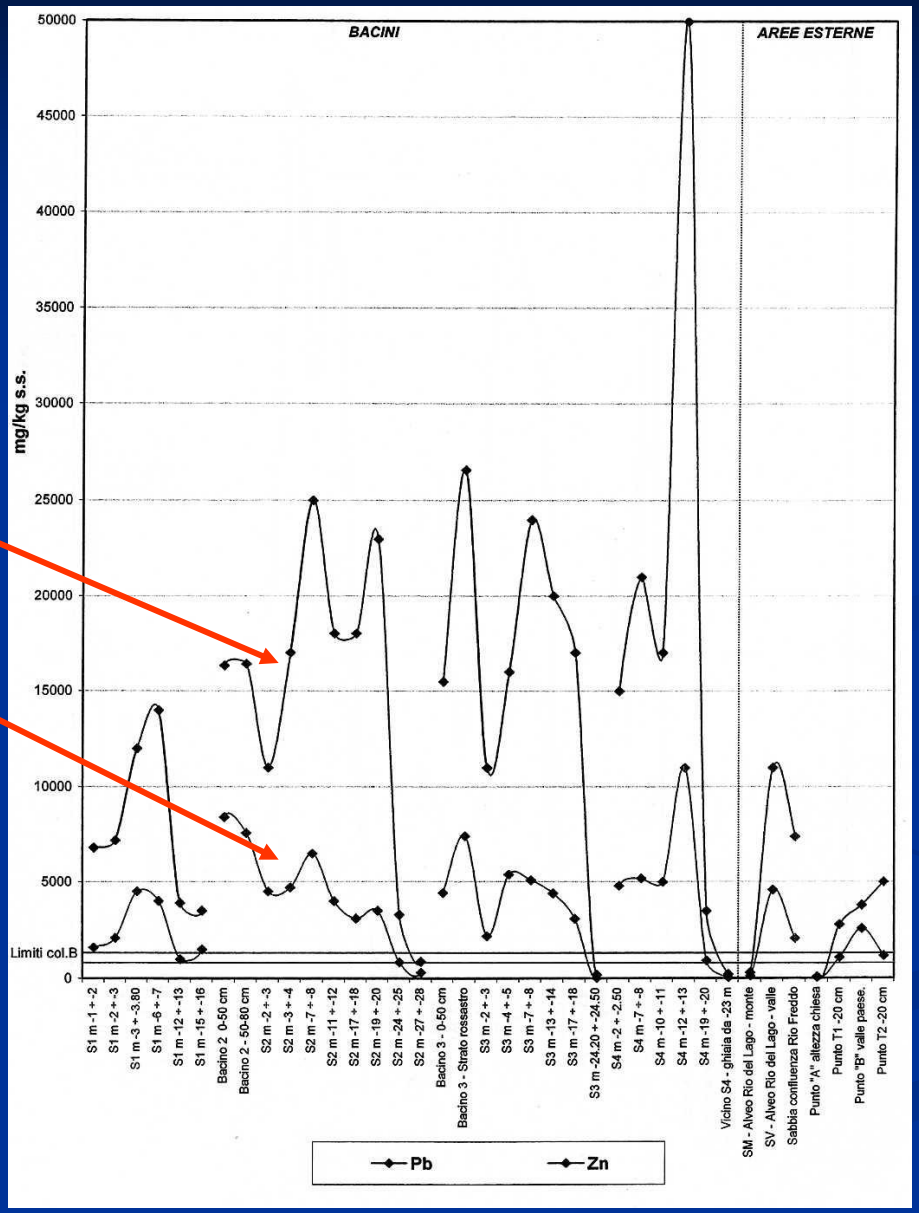
Elemental content of tailings (in $\mu g\ g^{-1}$)

Element	Mine tailings	Background (soil)		IT limits for industrial Sites
		Natural	Anthropogenic	
As	26 – 1400	1.7	23	50
Cd	0.6 - 40.7	0.3	3.0	15
Cu	11 – 560	2.2	31	600
Ni	7 – 69	2.2	10	500
Pb	930 - 11,000	38	617	1,000
Tl	33 – 330	1.1	6.9	10
Zn	870 - 50,000	96	1571	1,500

Horizontal profile of tailings

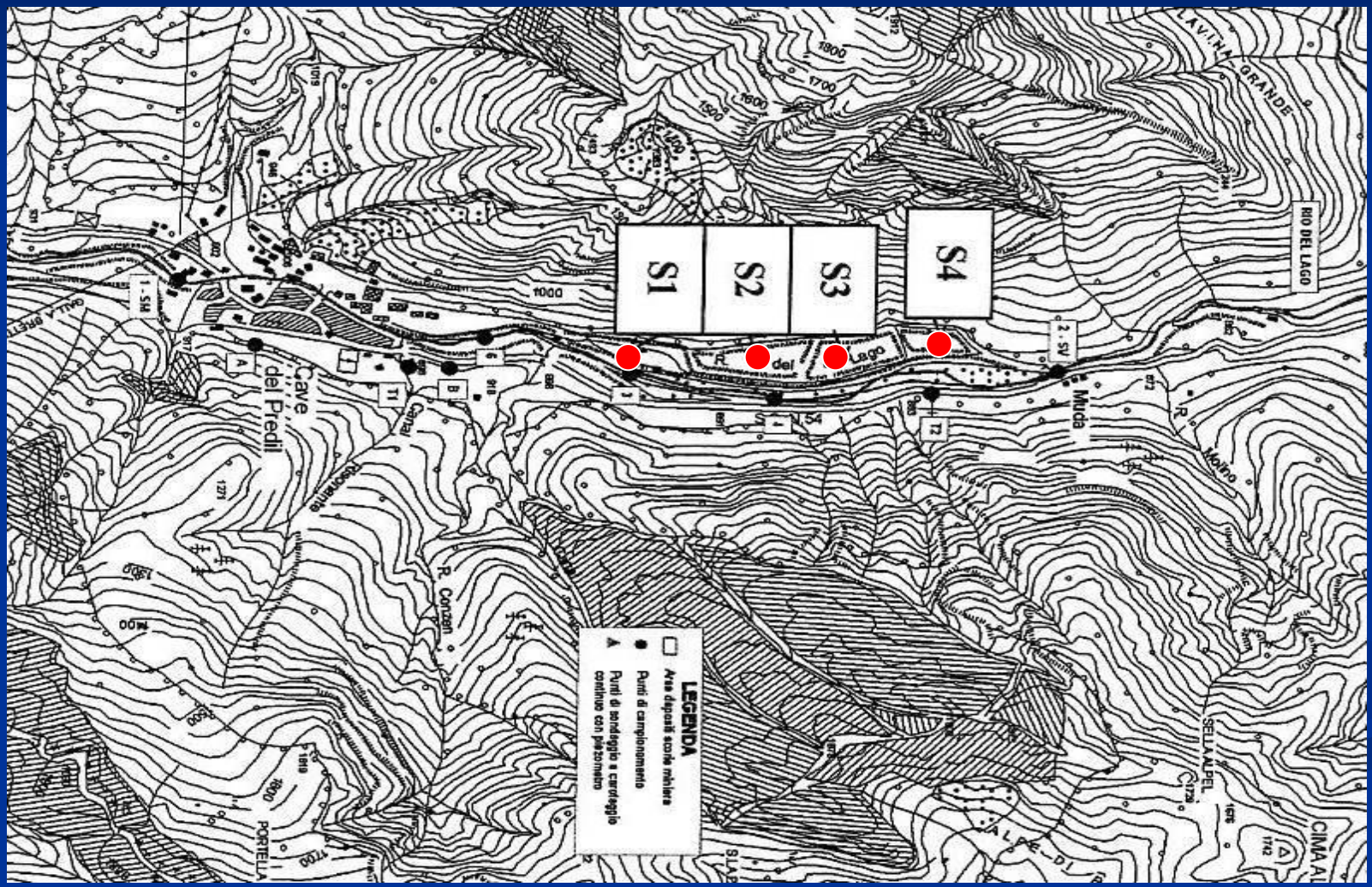
Zn

Pb




Runoff - Erosion
River Rio del Lago

Monitoring infiltration water



Total metal content in drainage water

Element	Ground water	Surface water
	mg L^{-1}	
As	<1 – 35	< 1
Cd	<0.5 – 1	< 1
Cu	1 – 5	1 – 2
Ni	<1 – 6	< 1
Pb	26 – 69	1 – 49
Tl	40 – 4000	<1 – 16
Zn	750 – 6600	2 – 575

4. Soil sealing

permanent covering of soil with an impermeable material

4. Soil sealing

Streets

Urbanize areas

Industrial areas

landfills

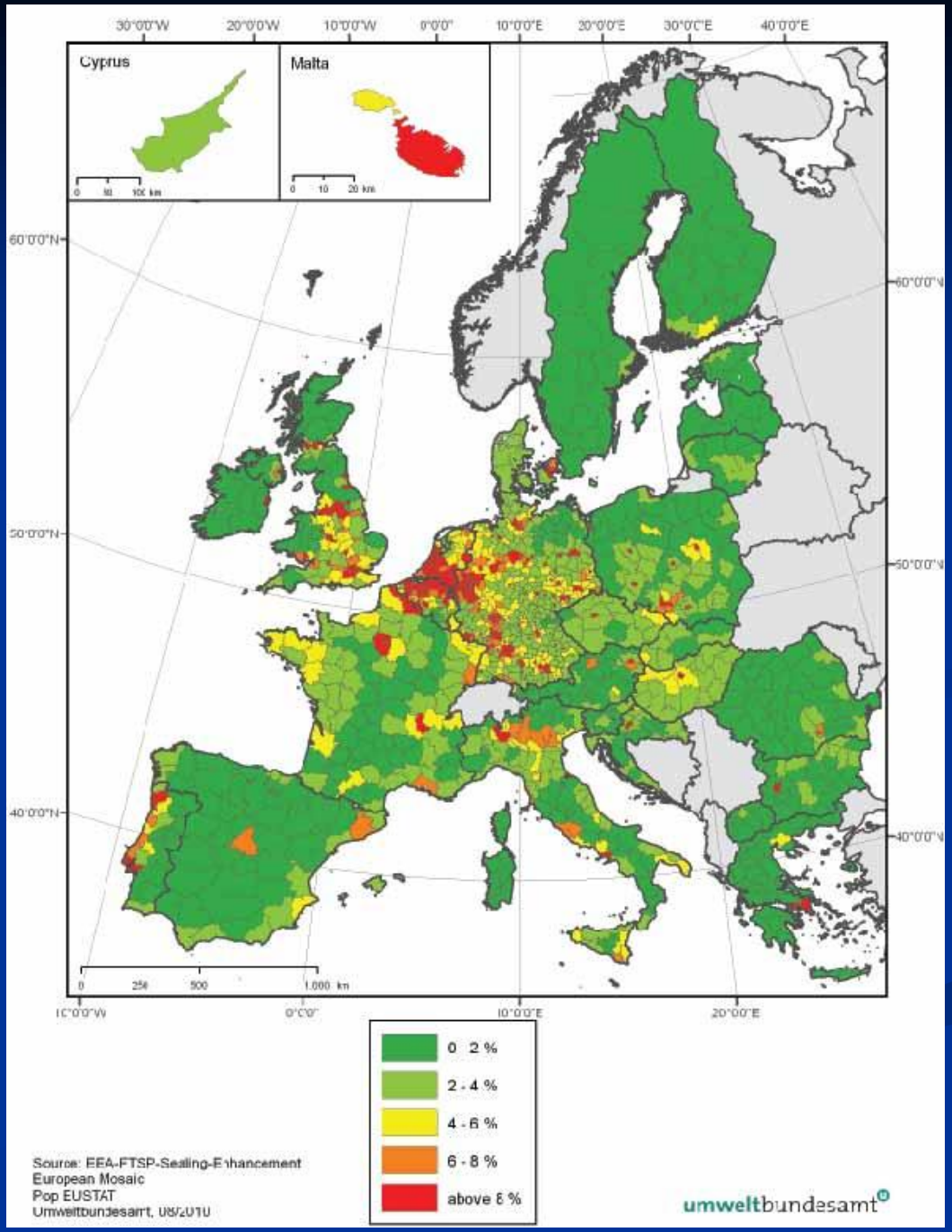
Agricultural struct

9% of total surface

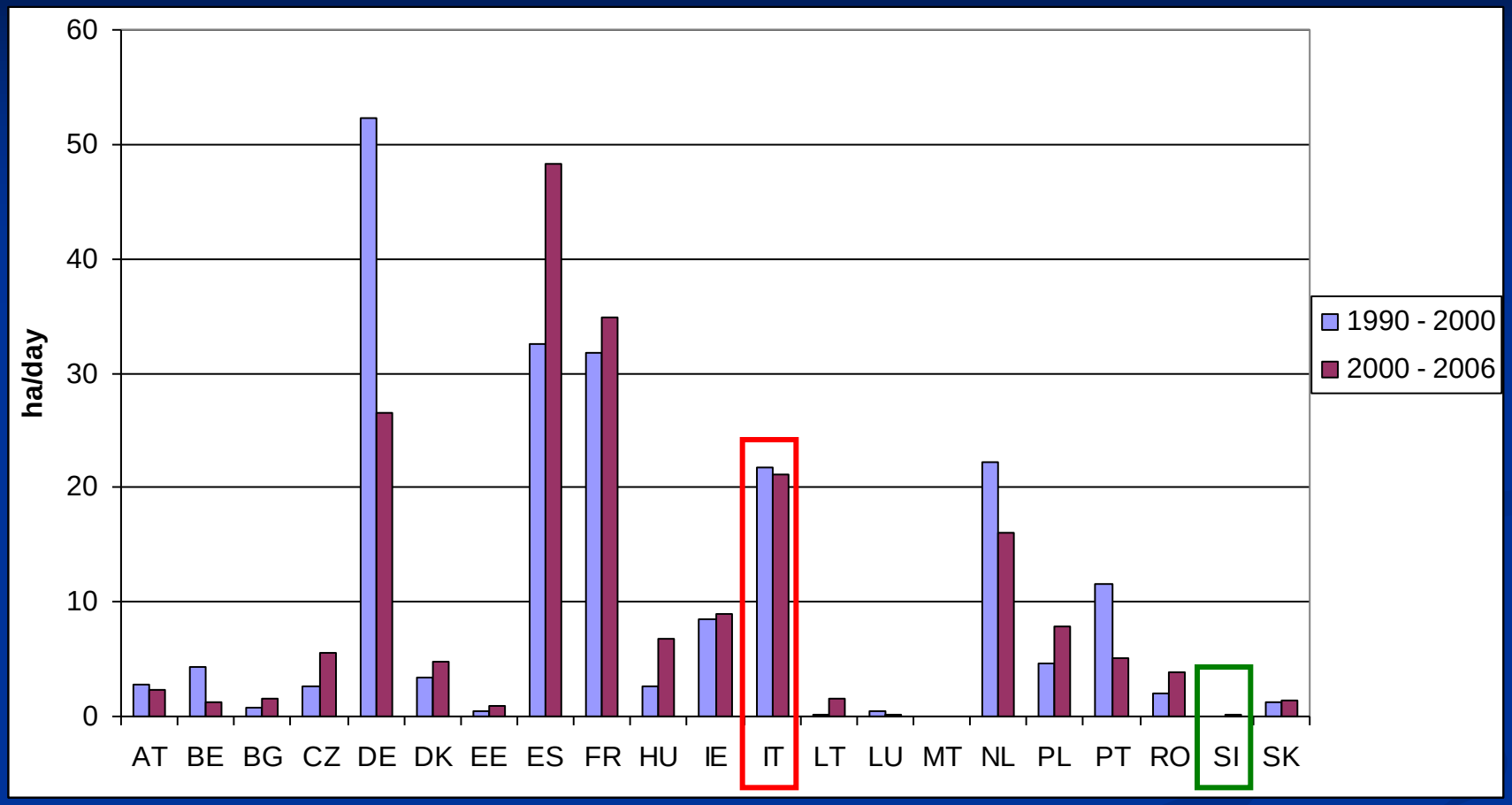
In Europe

4. Soil sealing

Sealed surface in 2006 (Prokop et al., 2011).

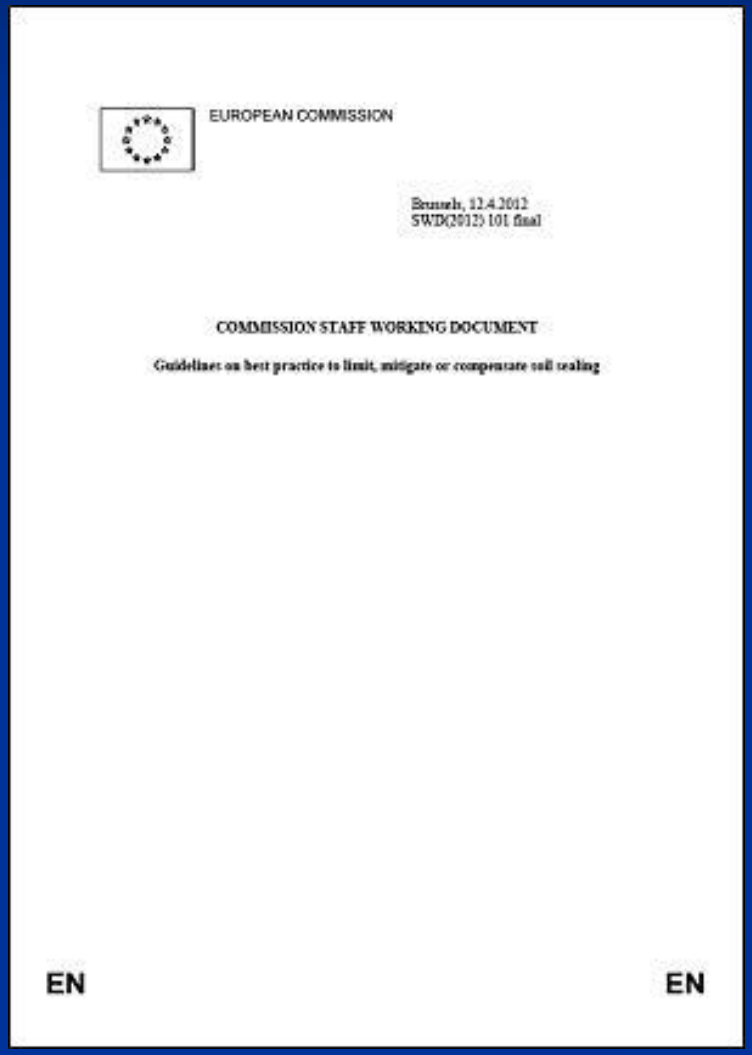


Daily soil consumption (Gardi et al., 2012)



Ca. 1000 km^2/year land take in the EU
(Ca. 250 ha/day)

Guidelines on best practice to limit, mitigate or compensate soil sealing



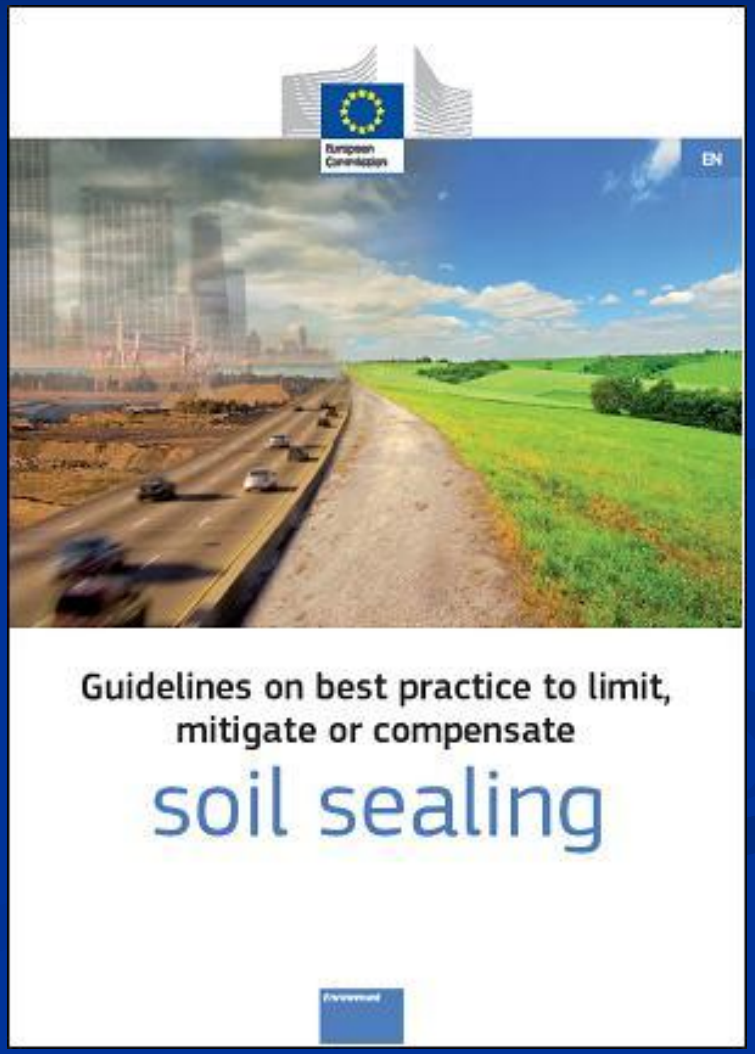
EUROPEAN COMMISSION

Brussels, 12.4.2012
SWD(2012) 101 final

COMMISSION STAFF WORKING DOCUMENT

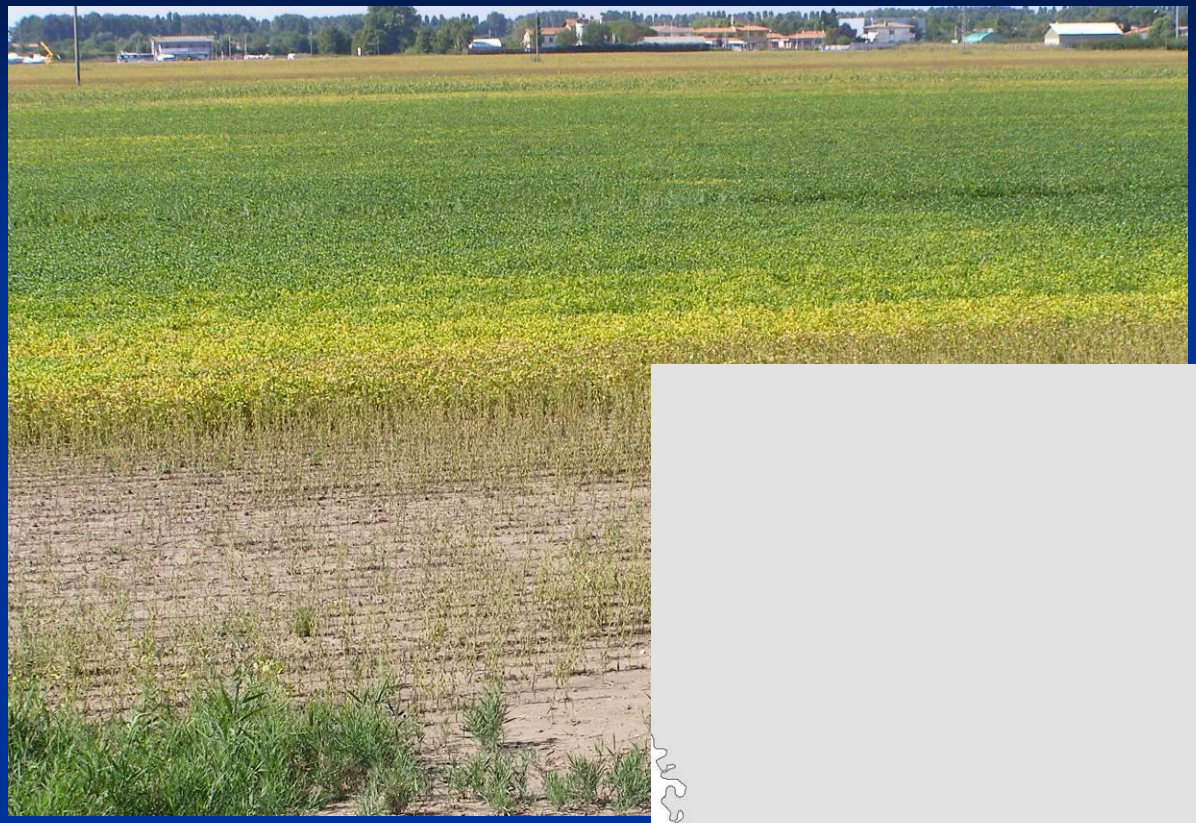
Guidelines on best practice to limit, mitigate or compensate soil sealing

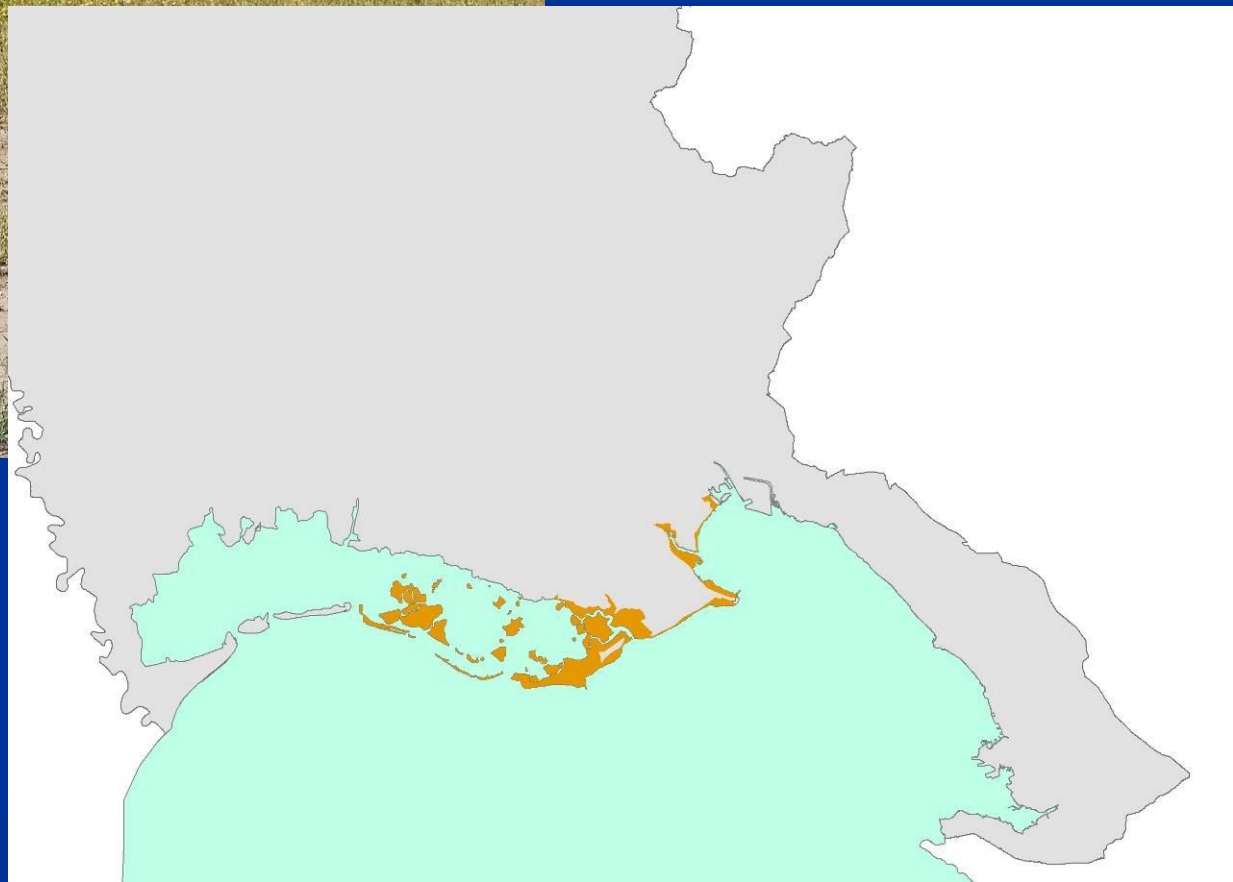
EN EN



5. Soil Compaction

7. Salinisation





EU Thematic Strategy for Soil Protection adopted by the European Commission on 2006

http://ec.europa.eu/environment/soil/index.htm

Thematic Strategy for Soil Protection

3 Components (Adopted by Commission 22/9/2006):

- **DIRECTIVE** establishing a framework for the protection of soil risk from erosion, compaction, salinisation, decline of soil organic matter, landslides, *contamination, sealing and loss of soil biodiversity*
- **COMMUNICATION** on the Thematic Strategy for Soil Protection: Why further action is needed?
- **IMPACT ASSESSMENT Report**: Analysis of economic, social and environmental impacts

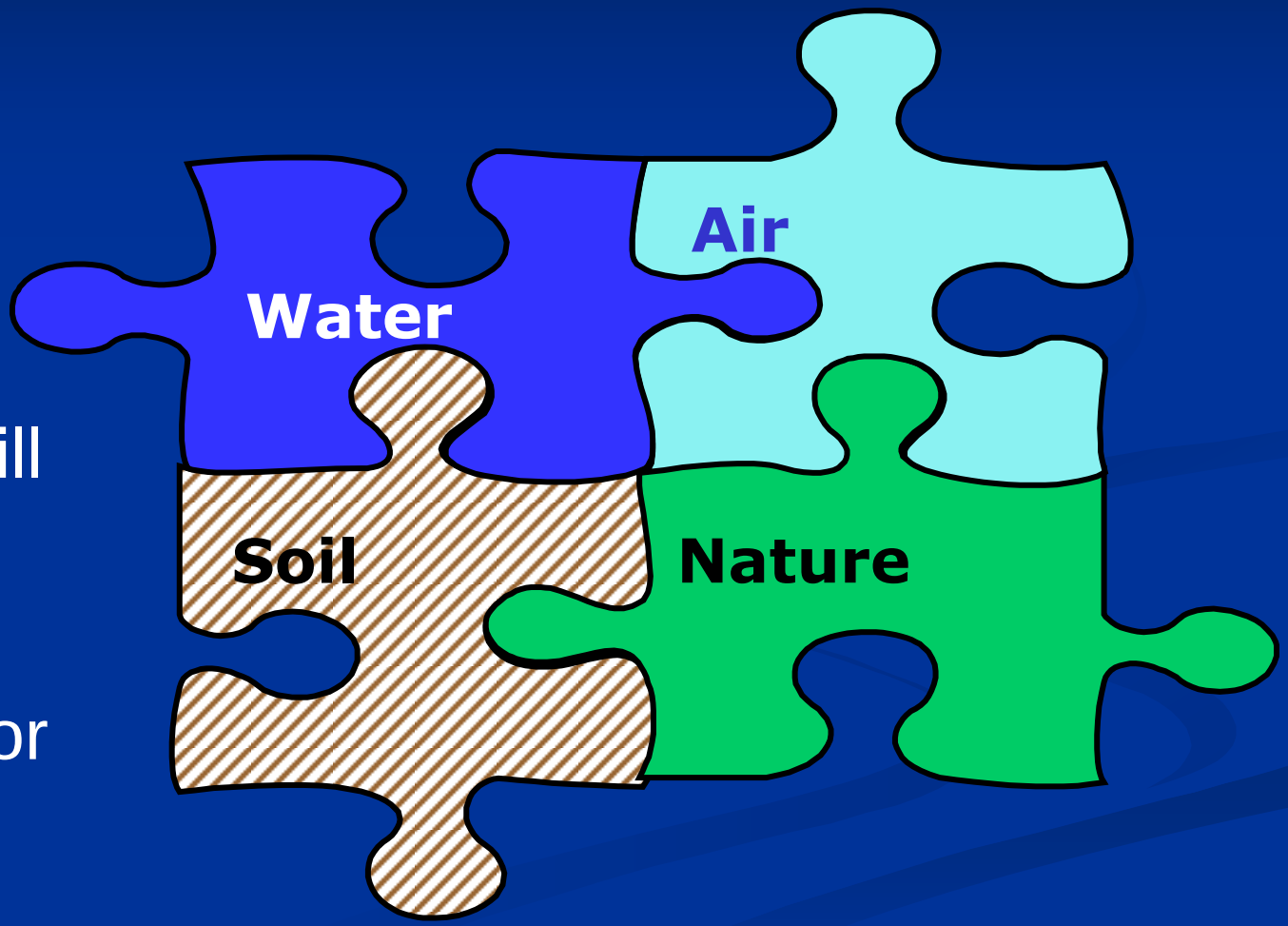
The strategy is one of 7 Thematic Strategies that the Commission has presented. The other strategies cover **air pollution**, the **marine environment**, **waste prevention and recycling**, **natural resources**, the **urban environment** and **pesticides**.

- Soil is a non-renewable natural resource
- It performs crucial ecological, social and economic functions for human activities and ecosystems survival
- Soils are being increasingly degraded or irreversibly lost across the EU
- There is a need for a comprehensive protective approach

- Estimated costs of soil degradation reach up to €38/$50 billions per year.
- Costs of soil degradation are mainly borne by society at large and not by the land user.
- The benefits of soil protection far outweigh the costs.

At EU level, there is legislation on…

… but we still miss a regulatory framework for soil



Overall objective

- **Preventing** further soil degradation and preserving its functions:
  - when soil is used and its functions are exploited, action has to be taken on soil use and management patterns, and
  - when soil acts as a sink/receptor of the effects of human activities or environmental phenomena, action has to be taken at source.

- **Restoring** degraded soils to a level of functionality consistent at least with current and intended use, thus also considering the cost implications of the restoration of soil.

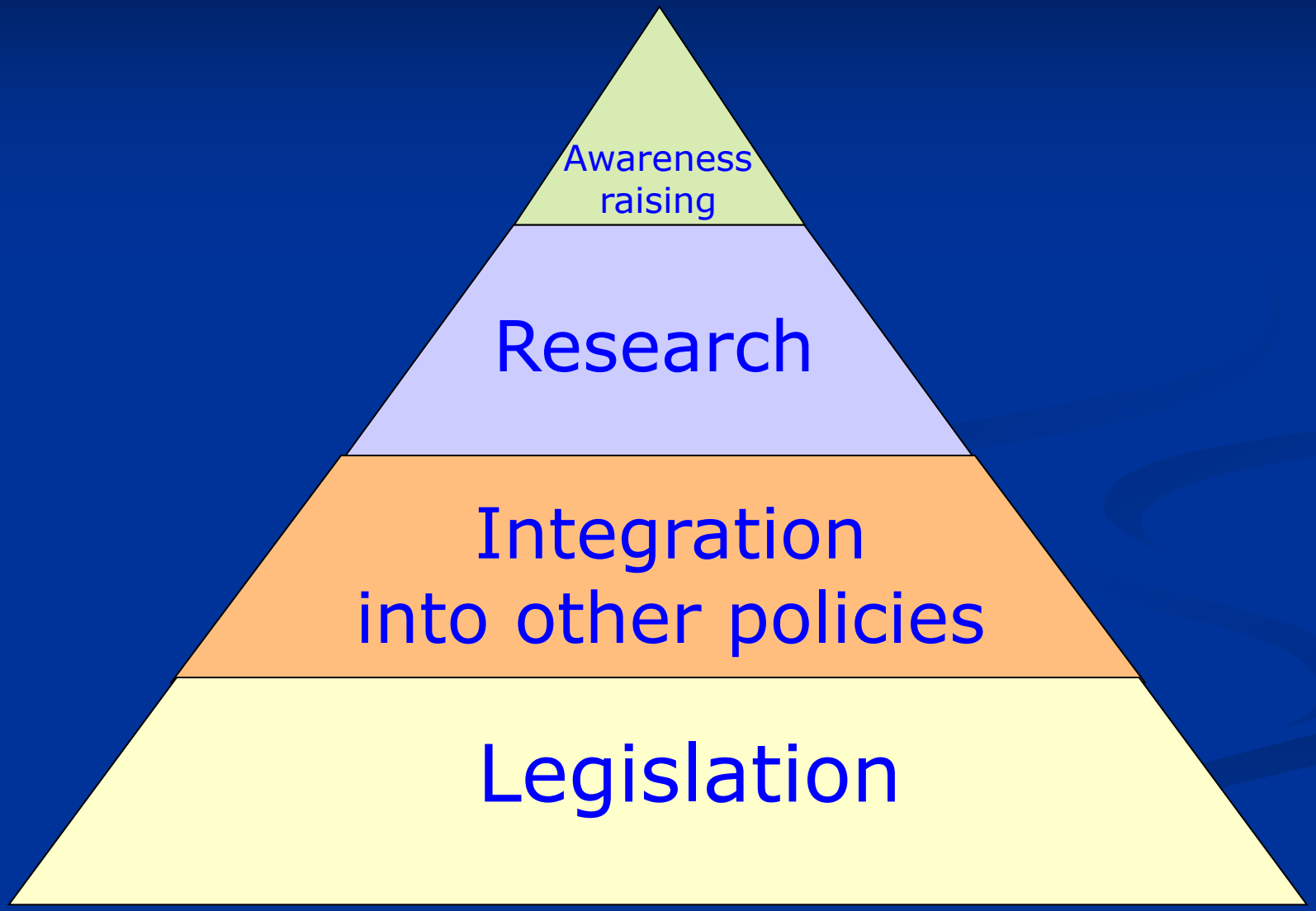
Why act at EU Level?

- Soil is a non renewable natural resource of common interest to Europe.
- European environmental legislation is incomplete without soil policy
- Soil degradation has transboundary consequences
- Differences among Member States in dealing with soil problems may distort competition within the single market
- As soil contamination may affect the quality of food and feed products
- The health of the European population can be impaired as a result of soil degradation

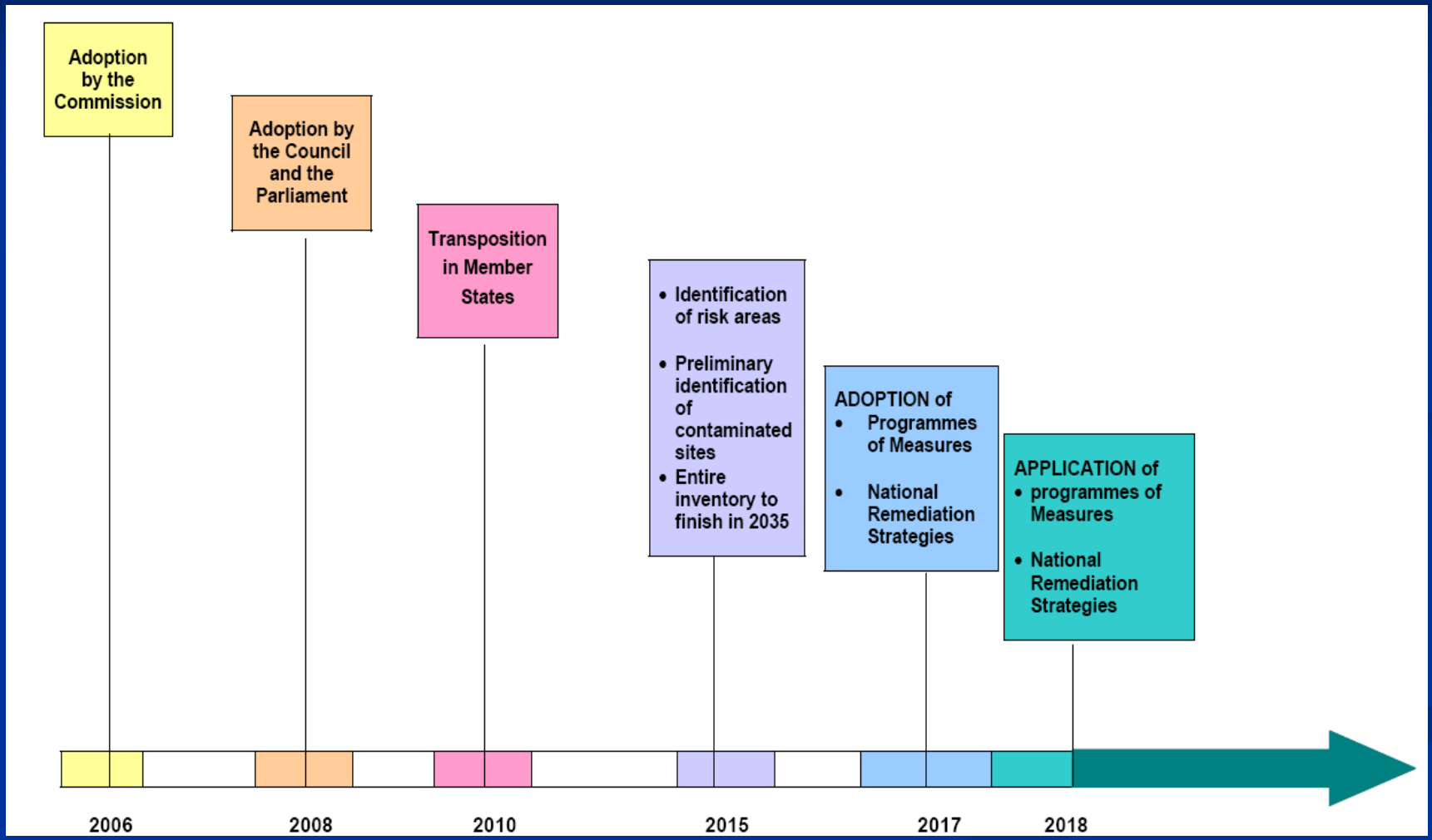
Four main pillars of EU Soil Policy

- **Framework legislation** with protection and sustainable use of soil as its principal aim;
- **Integration** of soil protection in the formulation and implementation of national and Community policies;
- **Research** supported by Community and national research programmes;
- **Public awareness** of the need to protect soil

Four main pillars of EU Soil Policy



Timetable for Soil Thematic Strategy



A nation that destroys its soils, destroys itself.

President Franklin D. Roosevelt, 1937.