University of Natural Resources and Applied Life Sciences, Vienna
Department of Forest- and Soil Sciences

RESPONSIBLE USE OF SOIL AND LAND AND REGIONAL DEVELOPMENT

by

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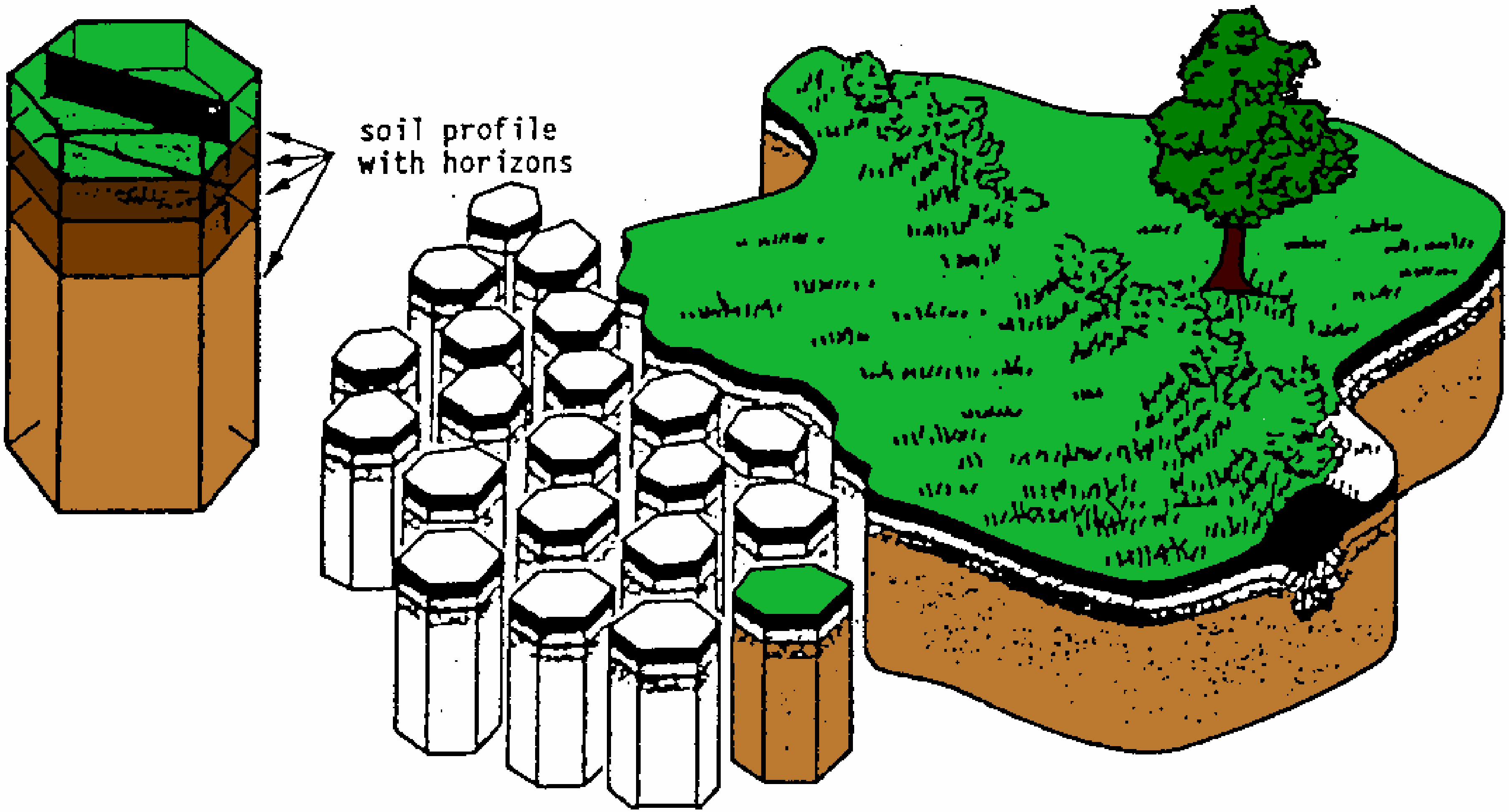
- **WHAT IS RESPONSIBLE USE OF SOIL AND LAND?**
- **WHAT MEANS REGIONAL DEVELOPMENT?**

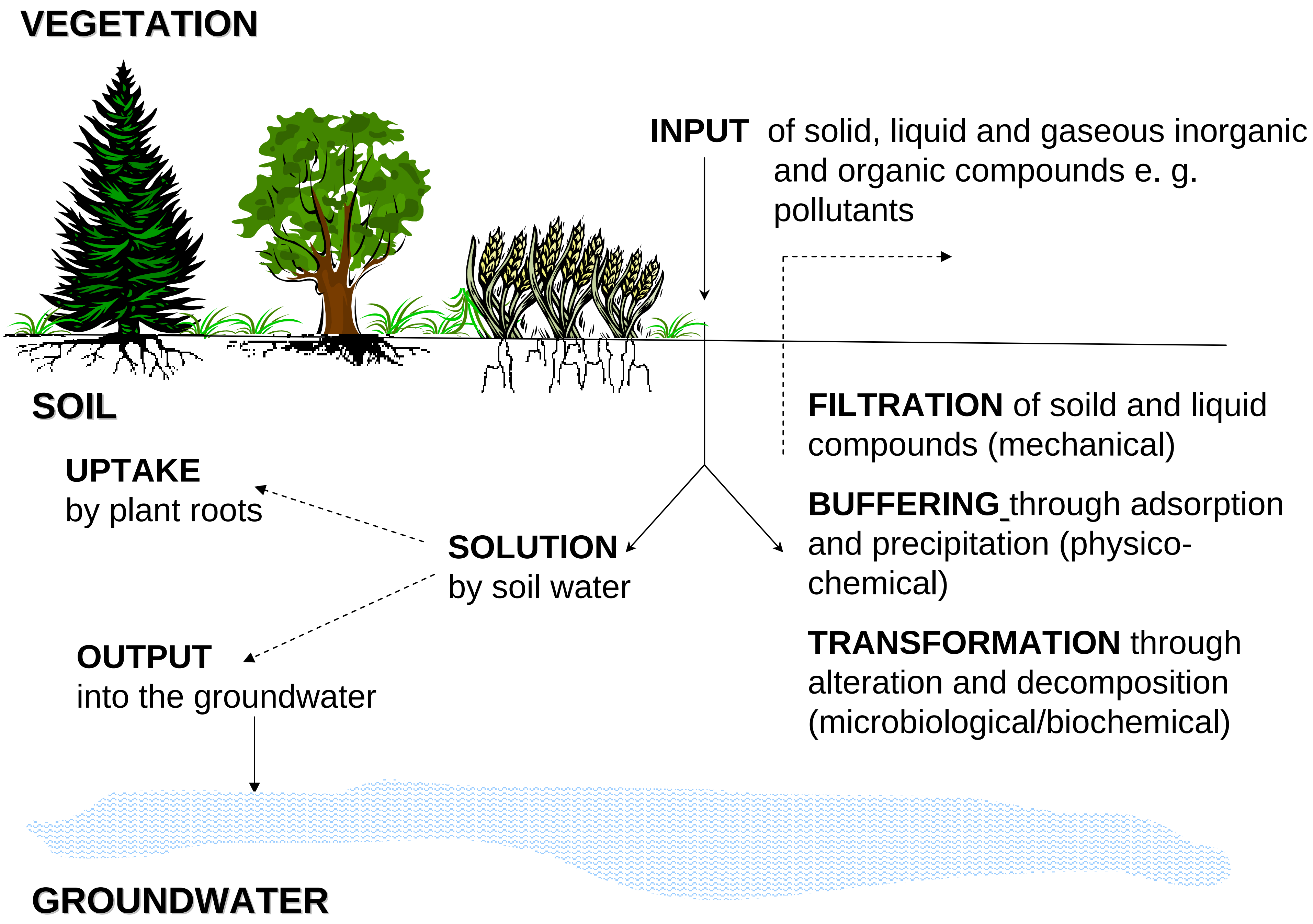

soil profile
with horizons

3 ECOLOGICAL FUNCTIONS AND USES:

1. PRODUCTION OF BIOMASS, ensuring food, fodder, renewable energy and raw materials

2. FILTERING, BUFFERING, and TRANSFORMATION between atmosphere, groundwater and plant cover protecting the environment

3. BIOLOGICAL HABITAT AND GENE RESERVE


VEGETATION
INPUT of solid, liquid and gaseous inorganic and organic compounds e. g. pollutants
SOIL
FILTRATION of soild and liquid compounds (mechanical)
UPTAKE by plant roots
BUFFERING through adsorption and precipitation (physico-chemical)
SOLUTION by soil water
OUTPUT into the groundwater
TRANSFORMATION through alteration and decomposition (microbiological/biochemical)
GROUNDWATER

Calculation of the Inner Surface of a Soil Volume

<u>Soil volume</u> (cut out) = 1 ha (100m x 100m) and 20 cm depth with a bulk density of 1.5 t m^{-3}

= 3000 t soil material

<u>Assumption</u>: soil volume containing

- **20% clay minerals (200 m² surface g^{-1})**
  = 600 t clay minerals
  = 600 Mio. x 200 = 120 Bio. m² = 120 000 km²
- **3% organic matter (humic substances) 1000 m² surface g^{-1}**
  = 90 t humic substances
  = 90 Mio x 1000 = 90 Bio. m² = 90 000 km²

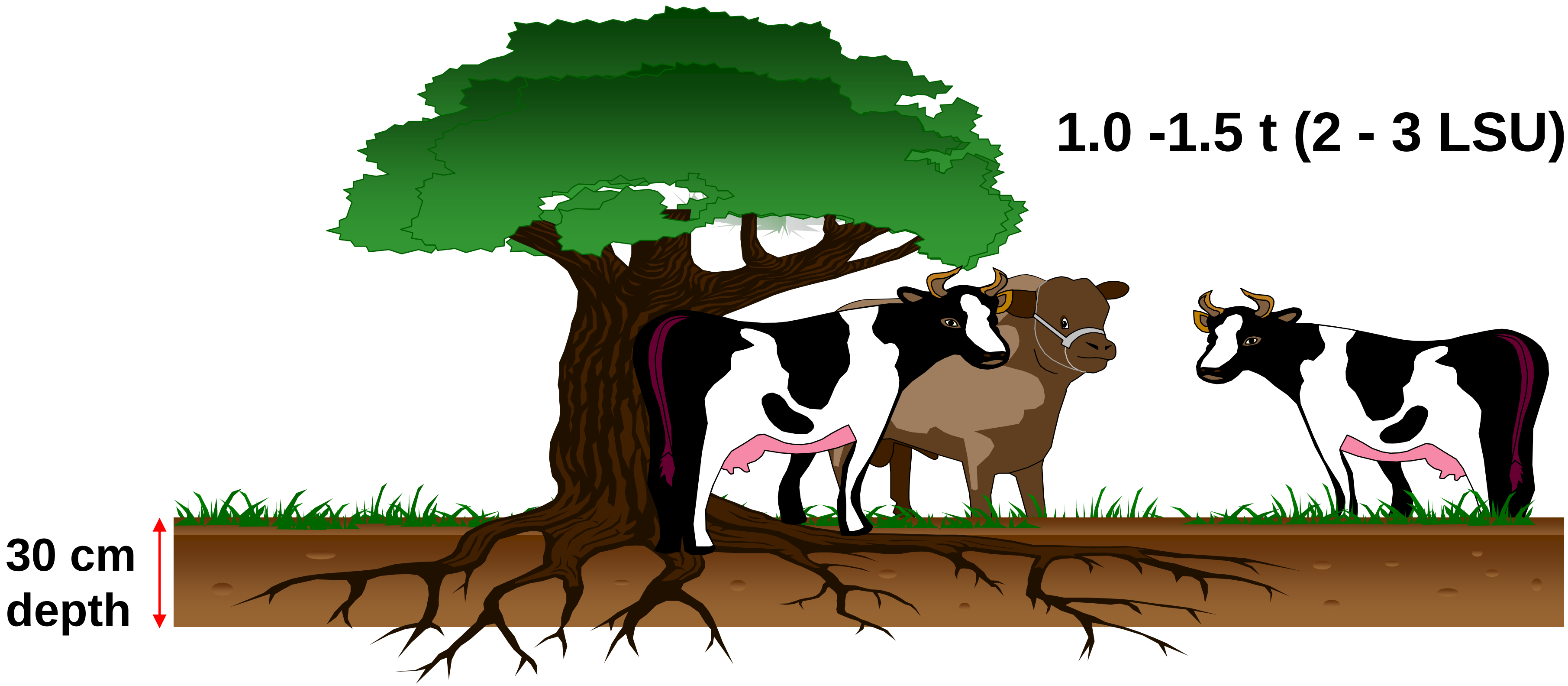
<u>Total surface</u> <u>= 210 000 km²</u>

<u>Example:</u>

The total land surface of Europe (= 10.531.000 km²) is contained in a soil volume of 7100 m x 7100 m (50,2 ha) and 20 cm depth.

Distribution of Biomass in a Pasture System

(per ha and 30 cm depth)



25 t Biomass
in the soil

10 t bacteria and actinomycetes
10 t fungi
4 t earth worms
1 t other soil animals

3 ECOLOGICAL FUNCTIONS AND USES:

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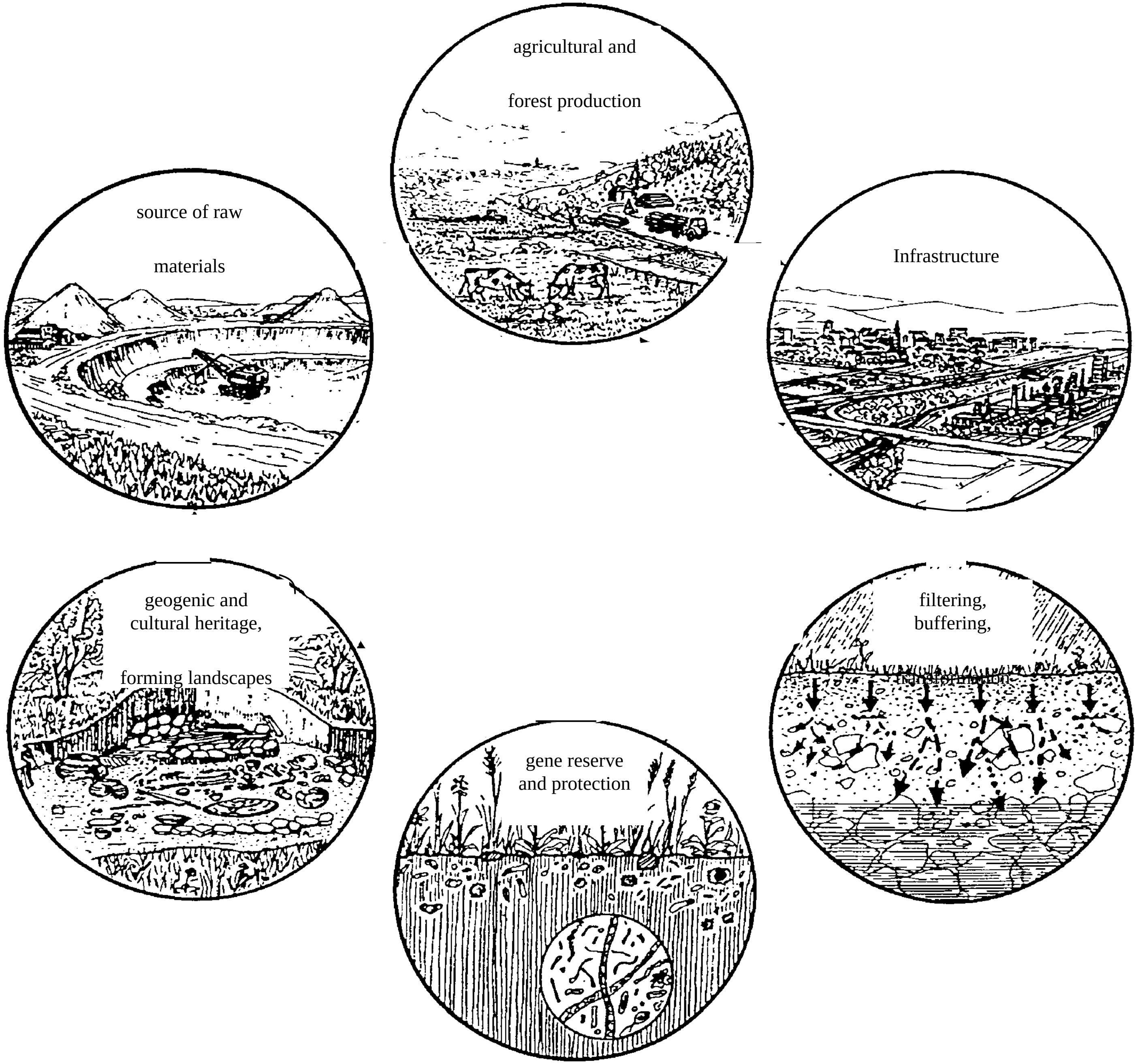
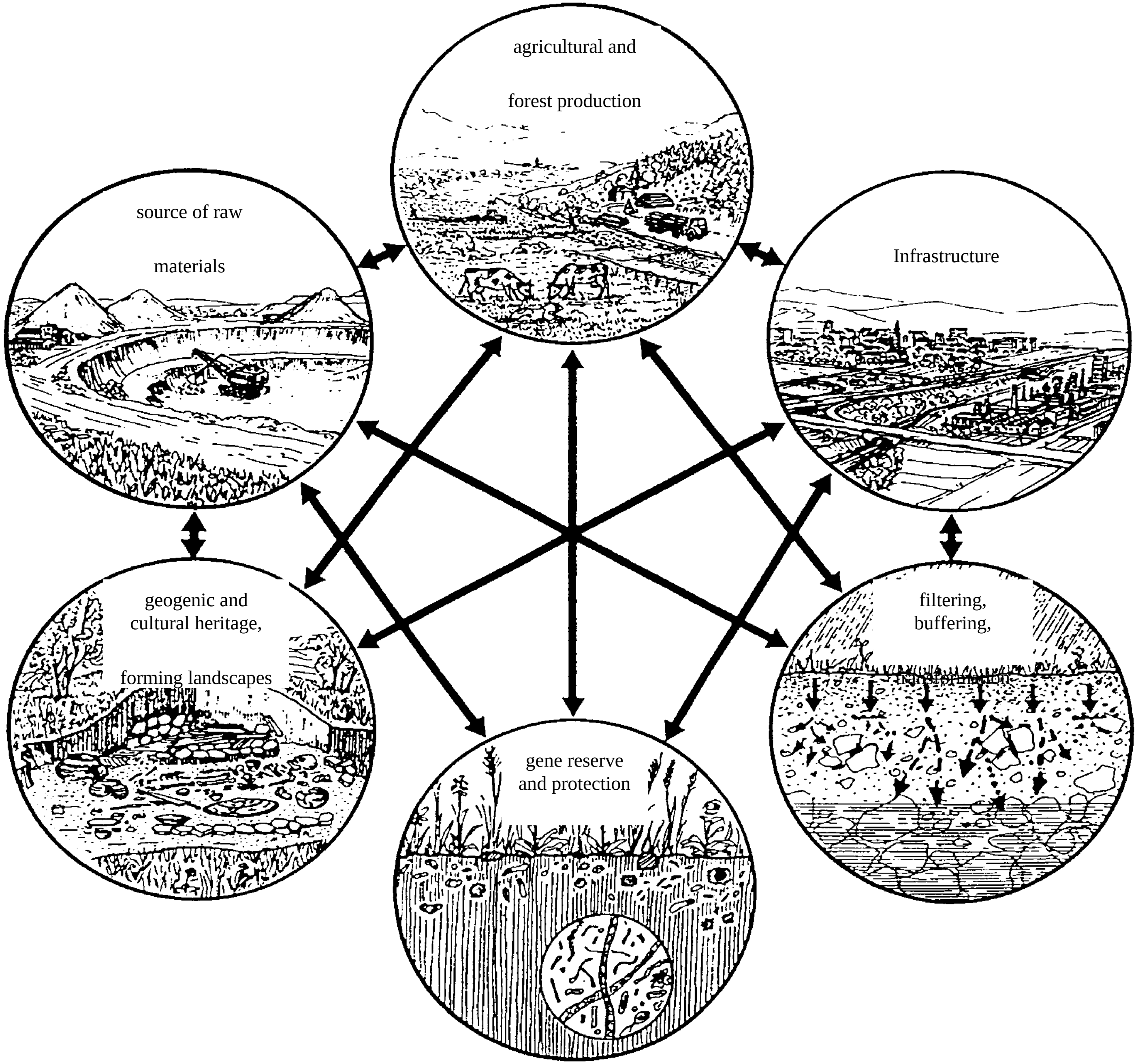
3 TECHNICAL, INDUSTRIAL AND SOCIO-ECONOMIC FUNCTIONS AND USES:

1. SPATIAL BASE FOR TECHNICAL, INDUSTRIAL AND SOCIO-ECONOMIC STRUCTURES AND THEIR DEVELOPMENT, e.g. industry, housing, transport, sports, recreation, dumping of refuse etc.
2. SOURCE OF GEOGENIC ENERGY, RAW MATERIALS AND WATER
3. GEOGENIC AND CULTURAL HERITAGE, forming an essential part of the landscape and concealing paleontological and archaeological treasures

THE SIX MAIN USES OF LAND



COMPETITION BETWEEN THE 6 SOIL FUNCTIONS



COMPETITION BETWEEN THE SIX MAIN USES OF SOIL AND LAND

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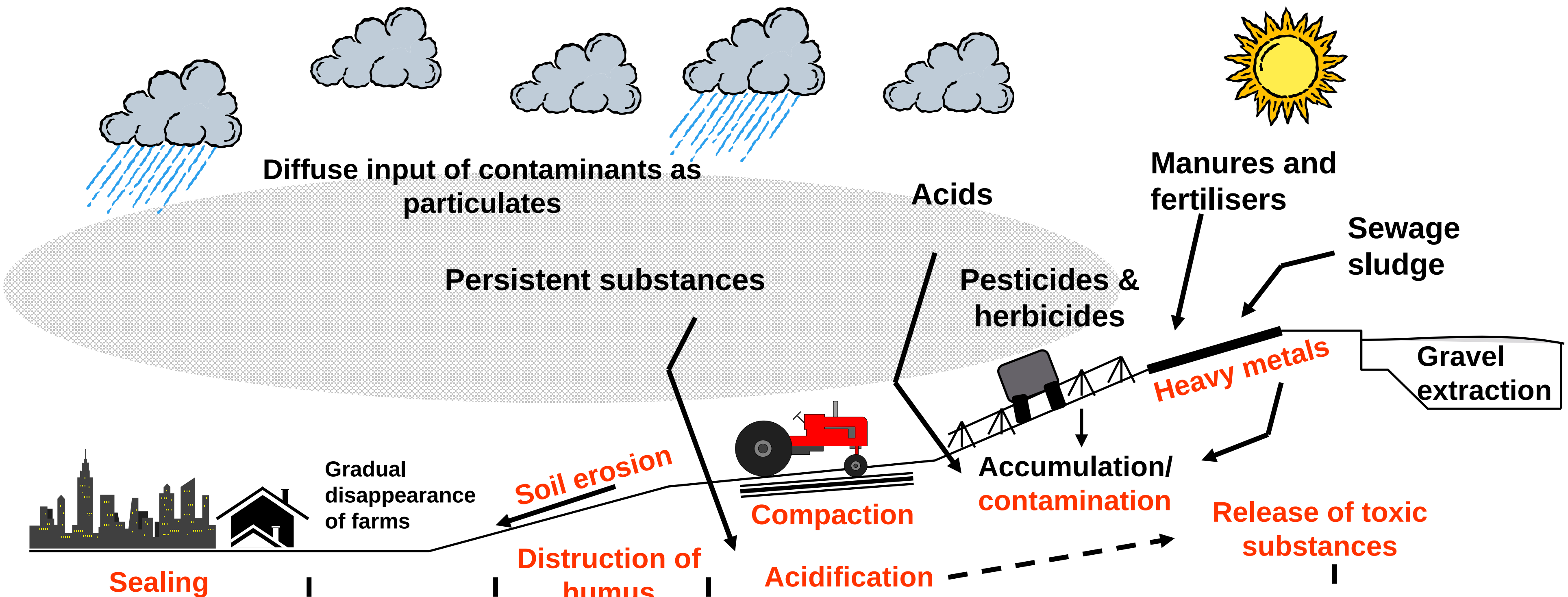
- Exclusive competition between the use of land for infrastructure, source of raw materials and geogenic and cultural heritage on the one hand and the agricultural and forest production, filtering, buffering and transformation activities as well as the soil as a gene reserve on the other;
- Intensive interactions between infrastructural land use and its development and agriculture and forestry, filtering, buffering and transformation as well as soil as a gene reserve;
- Intensive competition between the three ecological soil and land uses themselves.


European soil resources

Europe’s built environment

The impact of human activities on soil



Sealing

Blocking of soil functions important to the ecology of the landscape

Destruction of soil

Gradual disappearance of farms

Gradual destruction of soils

Reduction in soil fertility

Distruction of humus

Changes in the structure of soils

Reduction in soil fertility

Acidification / Accumulation/contamination

Contamination of soils and ground water with applied agrochemicals and atmospheric pollutants

Changes in soil composition

Adverse impacts on living organisms in the soil

Release of toxic substances

Destruction of soil

MAIN THREATS TO LAND AND SOIL

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- Sealing through urbanisation and industrialisation;
- Contamination (local and diffuse);
- Erosion by water and wind;
- Compaction and other forms of physical degradation;
- Decline in soil organic matter;
- Loss of biodiversity;
- Salinisation and acidification;
- Floods and land slides.

CLASSIFICATION OF IMPACTS IN ORDER OF URGENCY

1. IRREVERSIBLE*) DAMAGE/THREAT:

- soil loss through sealing, extraction of materials, mining and erosion (by water/wind);
- intensive pollution by heavy metals, xenobiotics, radioactive compounds;
- advanced acidification;
- deep-reaching compaction.

2. REVERSIBLE*) DAMAGE/THREAT:

- soil pollution by biodegradable organic compounds (mineralization, metabolisation);
- compacting, glazing and other deterioration of top soil structure.

***)** Definition of reversibility/irreversibility based on the time span of 100 years (~ 4 human generations).

Responsible use of soil and land means spatial and/or temporal harmonisation of all land uses in a given area, avoiding or minimising irreversible impacts.

This is not a scientific but a political issue (top down - bottom up decisions).

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ONE MAIN TOOL FOR TRANSLATING POLITICAL DECISIONS IS REGIONAL DEVELOPMENT

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INDICATORS FOR SUSTAINABLE REGIONAL DEVELOPMENT

- **Direct and indirect ecological, technical, socio-economic and cultural indicators can be distinguished.**

- **Examples:**

- ecological: soil quality, groundwater quality, air quality, biodiversity,
human health

- technical: access to public transport, availability of tools

- socio-economic: economic wealth, access to social resources

- cultural: educational level

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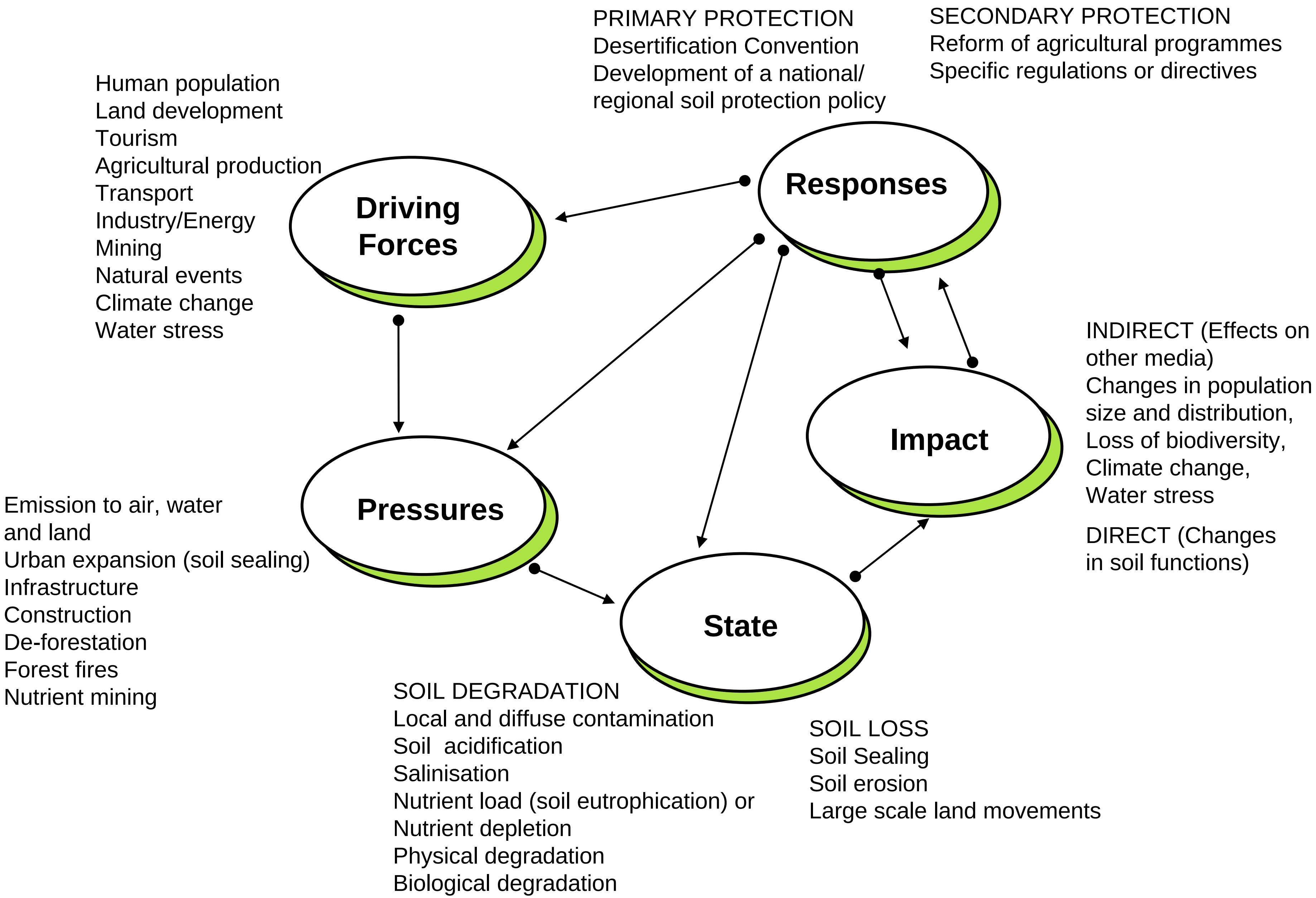
INDICATORS = INFORMATION

for understanding and managing complex systems.

Indicators can be cultural, social, economic, ecological or technical information.

The DPSIR Framework Applied to Soil



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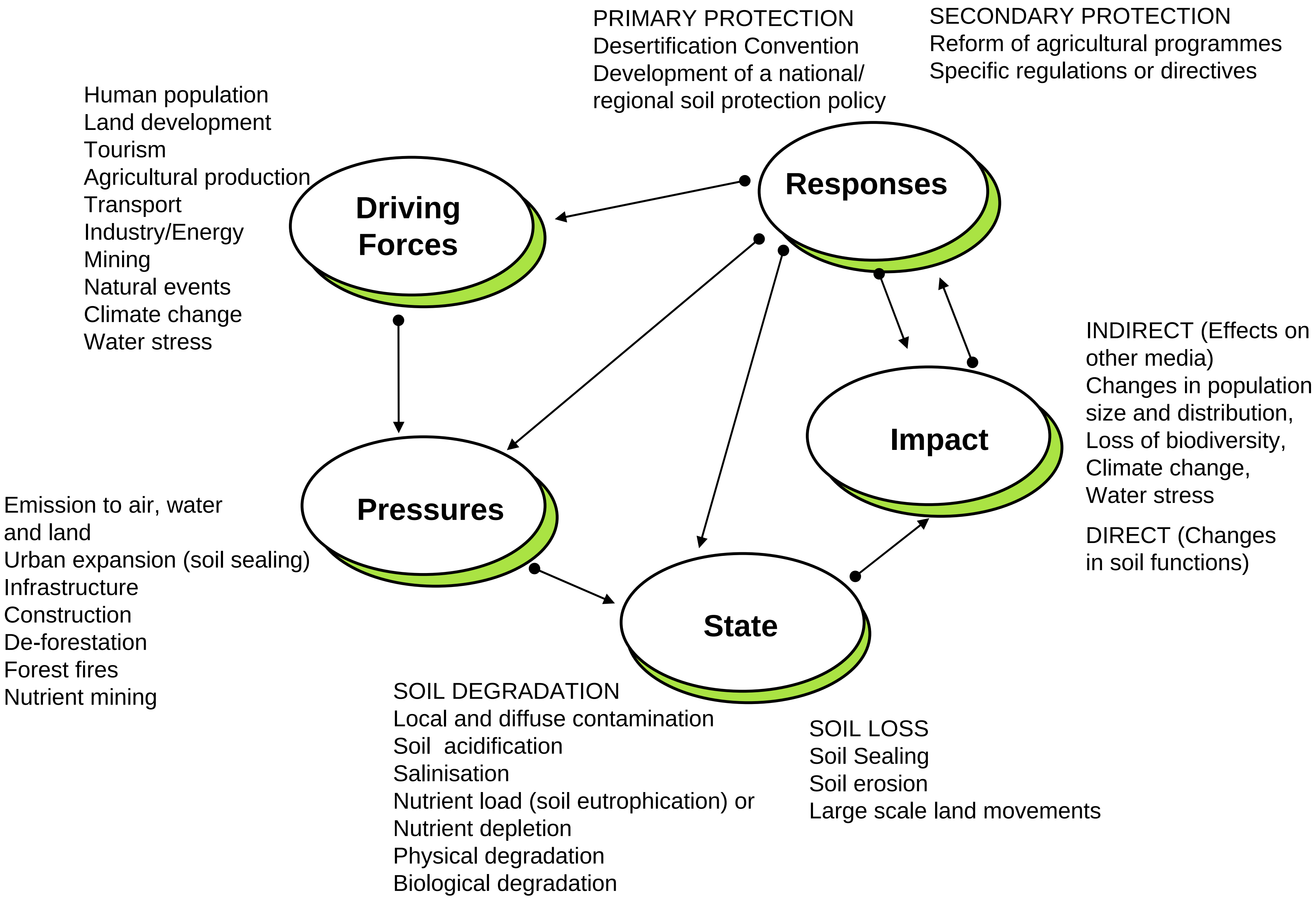
CRITERIA FOR INDICATORS

- policy relevant, focussing on real demand and less on the supply of data;
- analytically sound,based on science and revealing a clear cause-response relationship;
- easy to interpret and understandable for farmers at the grass-root level (stakeholders), as well as for decision makers and politicians;
- easily measurable and therefore feasible and cost effective in data collection, processing and dissemination.

The DPSIR Framework Applied to Soil



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DO WE NEED NEW RESEARCH CONCEPTS FOR DEFINING INDICATORS BASED ON DPSIR?

CONCEPT FOR INTEGRATED RESEARCH IN ECOLOGY – EXAMPLE SOIL

	MAIN RESEARCH GOALS	RESEARCH CLUSTERS (see Fig. enclosed)	SCIENCES INVOLVED
1	To understand the main processes in the eco-subsystem soil; induced by threats	Analysis of processes related to the 8 threats to soil and their interdependency: erosion, loss of organic matter, contamination, sealing, compaction, decline in biodiversity, salinisation, floods and landslides	Inter-disciplinary research through co-operation of soil physics, soil chemistry, soil mineralogy and soil biology
2	To know where these processes occur and how they develop with time	Development and harmonisation of methods for the analysis of the **State (S)** of the 8 threats to soil and their changes with time = **soil monitoring** in Europe	Multi-disciplinary research through co-operation of soil sciences with - geographical sciences, - geo-statistics, - geo-information sciences (e.g. GIS)
3	To know the driving forces and pressures behind these processes, as related to cultural, social, economic, ecological or technical, local, regional or global developments	Relating the 8 threats to **Driving forces (D)** and **Pressures (P)** = cross linking with EU and other policies (agriculture, transport, energy, environment etc.)	Multi-disciplinary research through co-operation of soil sciences with political sciences, social sciences, economic sciences, historical sciences, philosophical sciences and others
4	To know the impacts on the eco-services provided by the sub-system soil to other environmental compartments (eco-subsystems)	Analysis of the **Impacts (I)** of the 8 threats, relating them to soil eco-services for other environmental compartments: air, water (open and ground water), biomass production, human health, biodiversity	Multi-disciplinary research through co-operation of soil sciences with geological sciences, biological sciences, toxicological sciences, hydrological sciences, physio-geographical sciences, sedimentological sciences and others
5	To have operational tools (technologies) at one's disposal for the mitigation of threats and impacts	Development of operational procedures for the mitigation of the threats = **Responses (R)**	Multi-disciplinary research through co-operation of natural sciences with engineering sciences, technical sciences, physical sciences, mathematical sciences and others

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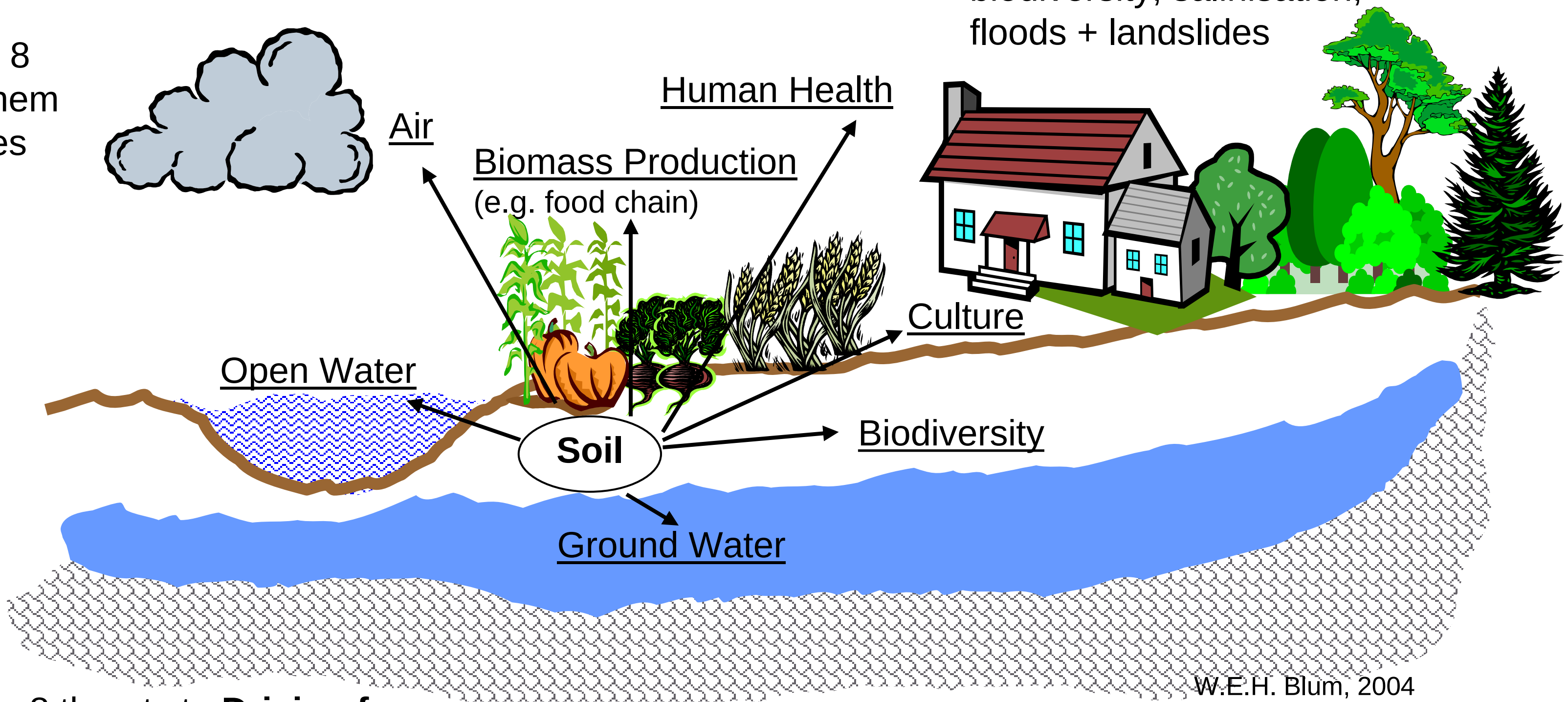
THE 5 MAIN SOIL RESEARCH CLUSTERS

5. Development of strategies and operational procedures for the mitigation of the threats = **Responses (R)**

1. Analysis of processes related to the 8 threats to soil and their interdependency: erosion, loss of organic matter, contamination, sealing, compaction, decline in biodiversity, salinisation, floods + landslides

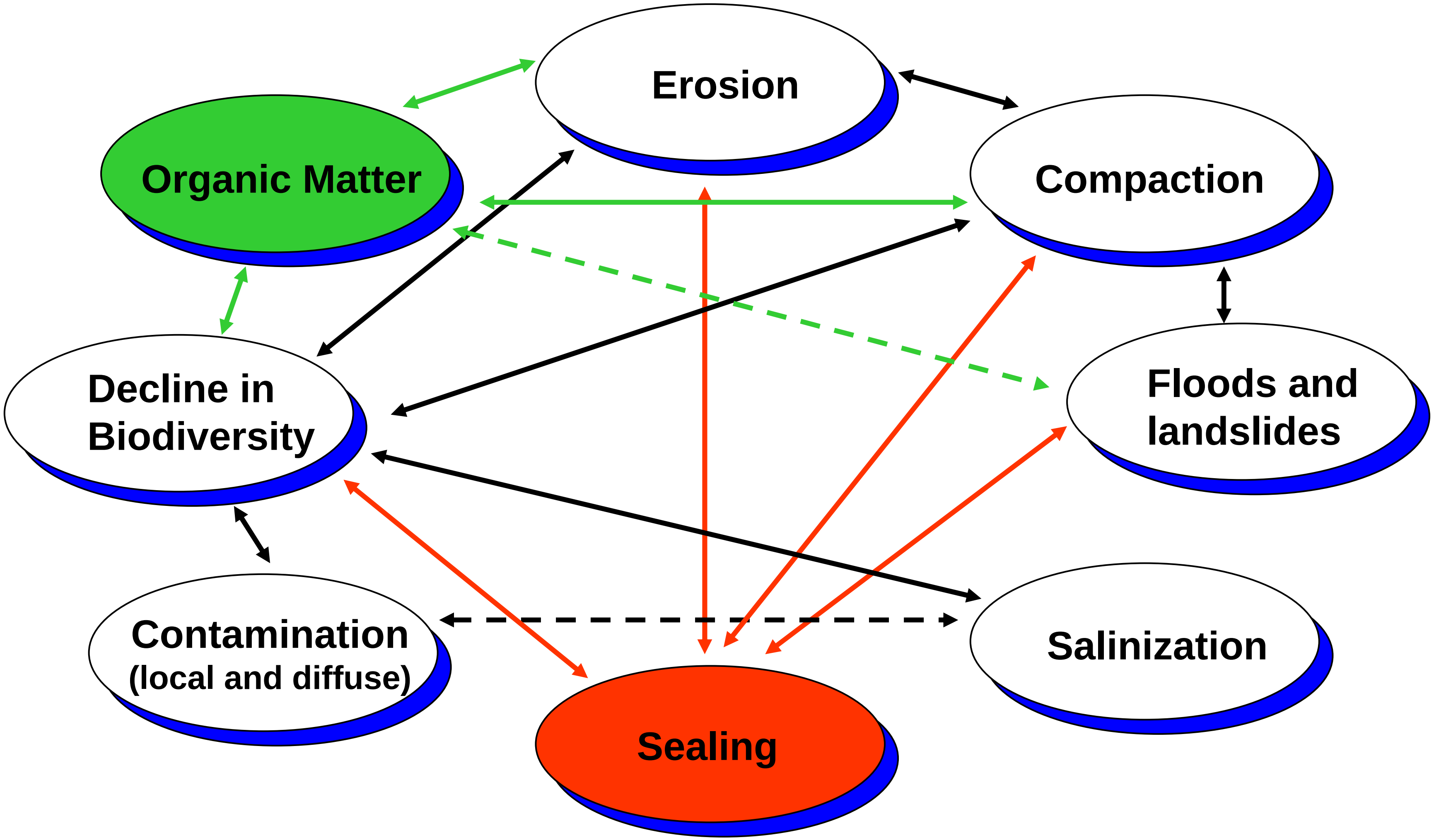
4. Analysis of the **Impacts (I)** of the 8 threats, relating them to soil eco-services for other environmental compartments:
- air
- water (open + ground water)
- biomass production
- human health
- biodiversity
- culture



3. Relating the 8 threats to **Driving forces (D)** and **Pressures (P)** = Cross linking with cultural, social and economic drivers, such as EU and other policies (agriculture, transport, energy, environment etc.) as well as technical and ecological drivers, e.g. global and climate change

2. Development, harmonisation and standardisation of methods for the analysis of the **State (S)** of the 8 threats to soil and their changes with time = **Soil monitoring** in Europe

THE 8 THREATS TO SOIL AND THEIR PROCESSURAL INTERDEPENDENCIES



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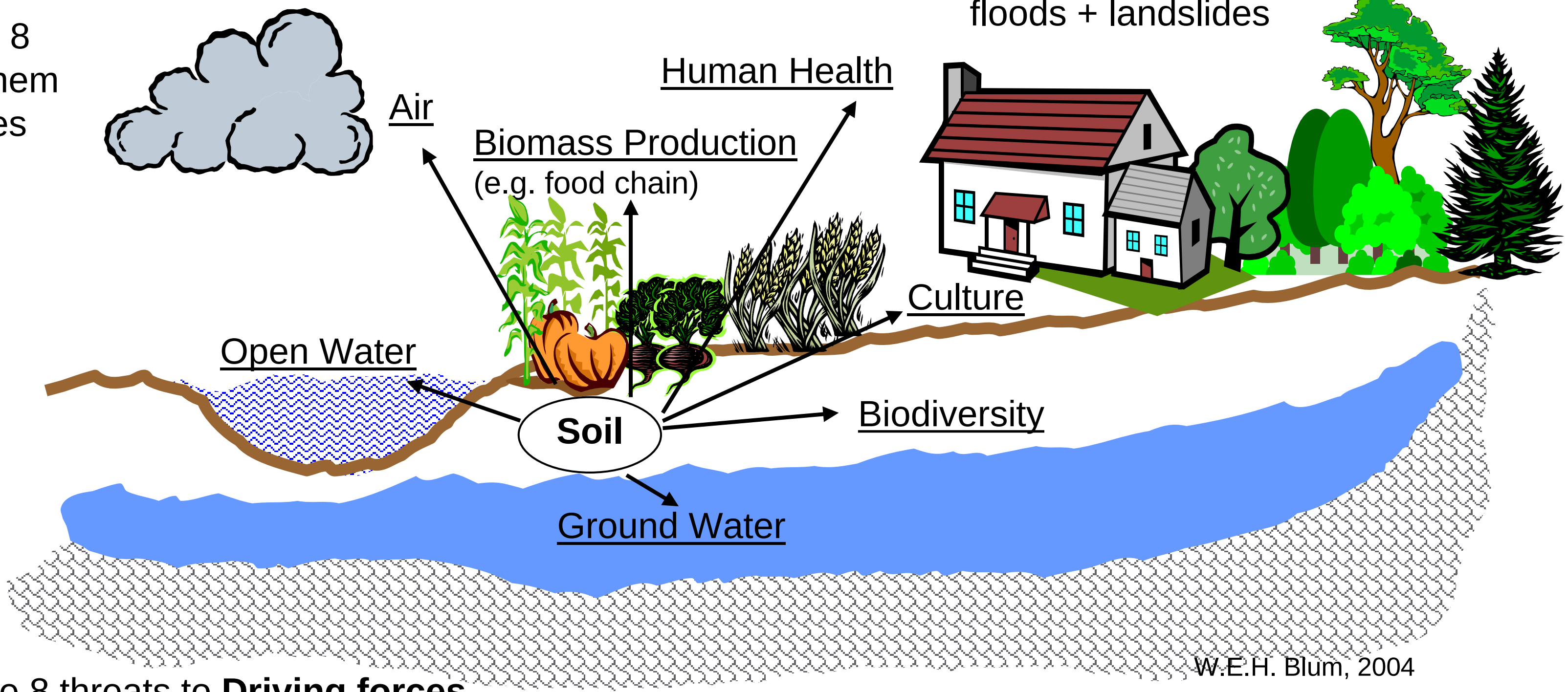

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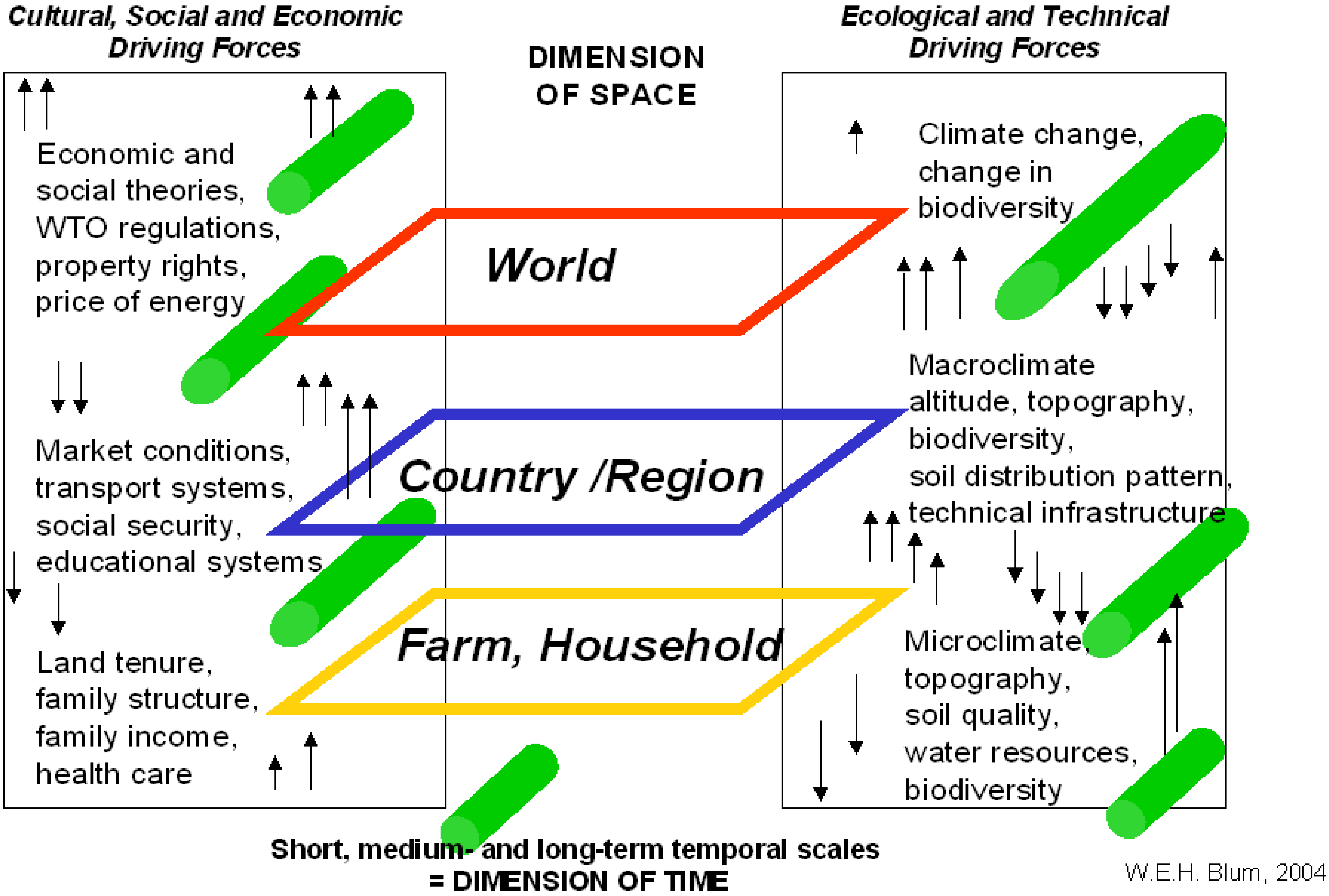
RELATING THE 8 THREATS TO D R I V I N G F O R C E S (D) AND P R E S S U R E S (P) THROUGH CROSS-LINKING WITH EU AND OTHER POLICIES.

THREATS:	EU AND OTHER POLICIES:
erosion	agriculture
organic matter	regional planning
decline in biodiversity	environment
compaction	transport
salinisation	energy
contamination (local and diffuse)	development
floods and landslides	single market (competition)
sealing	others ...

Fig. 2: DRIVING FORCES OF LAND AND SOIL DEGRADATION - DIMENSIONS OF SPACE AND TIME



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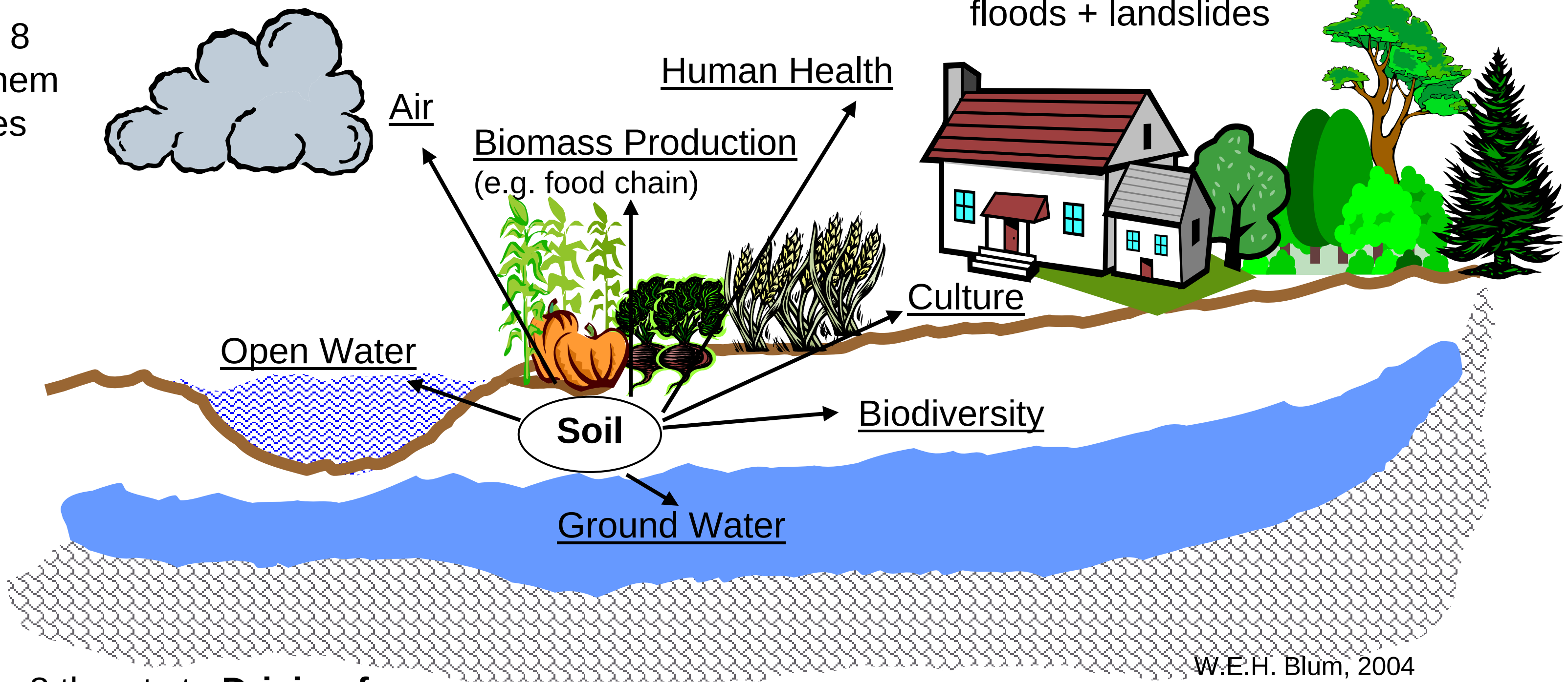

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2. Development, harmonisation and standardisation of methods for the analysis of the **State (S)** of the 8 threats to soil and their changes with time = **Soil monitoring** in Europe

ANALYSIS OF THE I M P A C T S (I) BY RELATING THEM TO THE SOIL DELIVERABLES INTO OTHER ECOLOGICAL DEPARTMENTS

THREATS:

erosion

organic matter

contamination

compaction

salinisation

floods and landslides

decline in biodiversity

SOIL DELIVERABLES INTO THE ECOLOGICAL DEPARTMENTS:

air

water (open water and ground water)

biomass production

human health

biodiversity

THE 5 MAIN SOIL RESEARCH CLUSTERS

5. Development of strategies and operational procedures for the mitigation of the threats = **Responses (R)**

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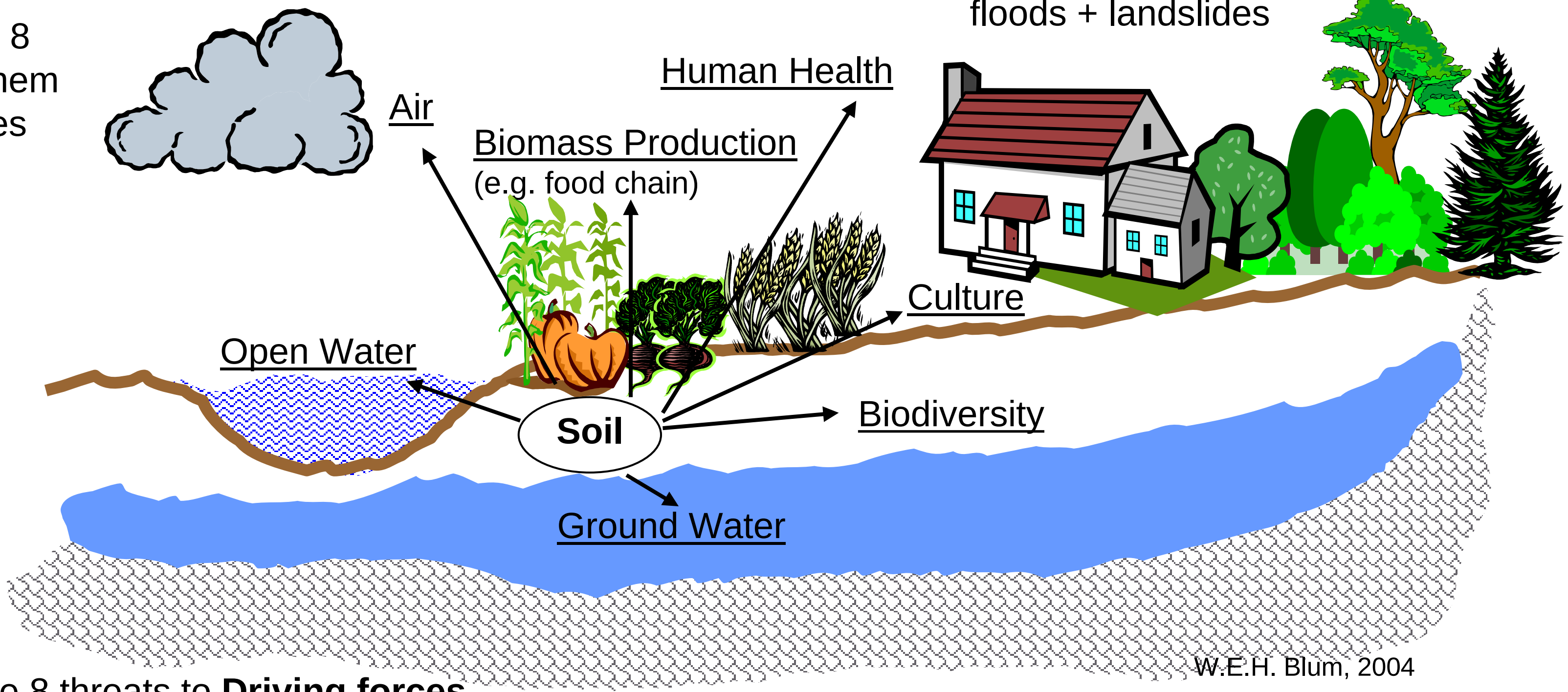

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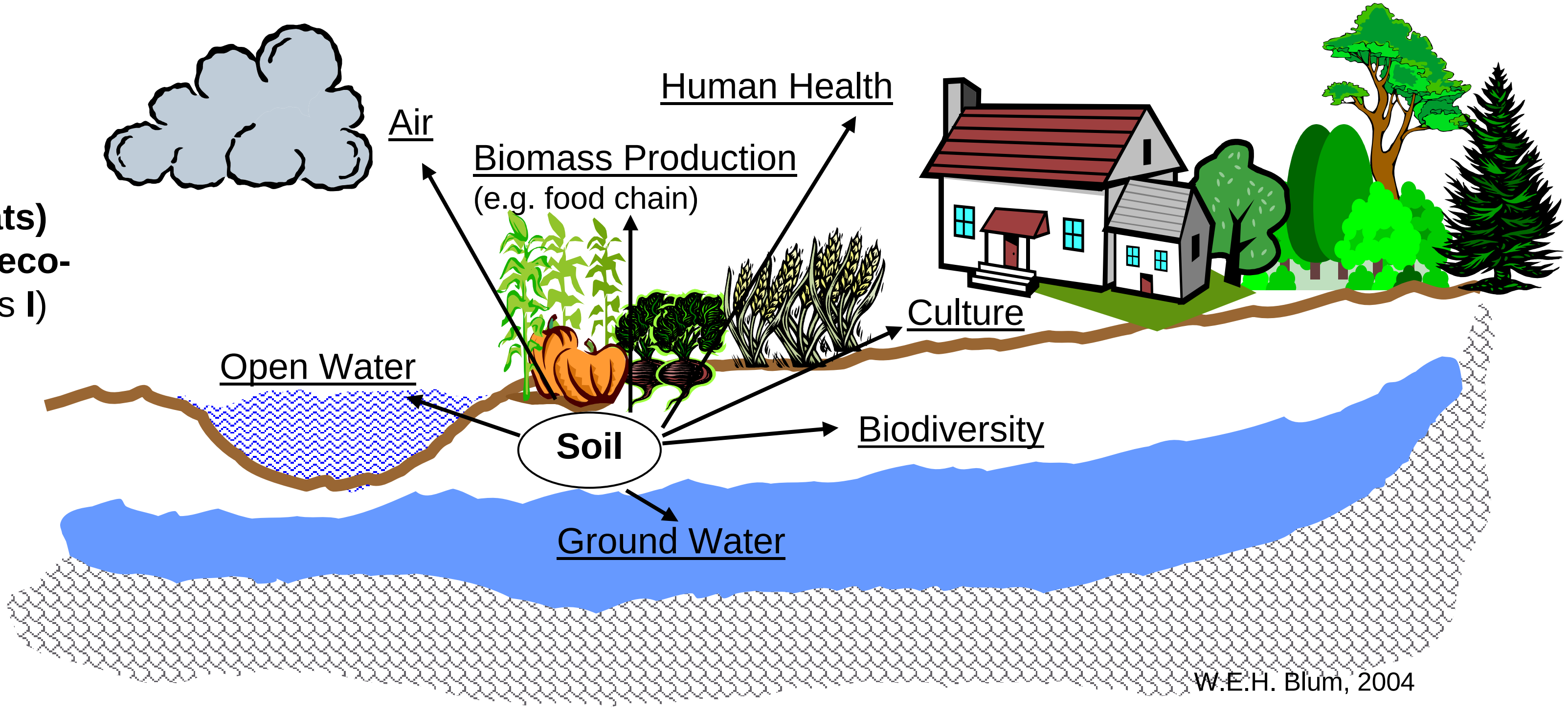
2. Development, harmonisation and standardisation of methods for the analysis of the **State (S)** of the 8 threats to soil and their changes with time = **Soil monitoring** in Europe

PRIORITY RESEARCH AREAS FOR SOIL PROTECTION AND THE MANAGEMENT OF EUROPE'S NATURAL RESOURCES BASED ON DPSIR

5. Strategies and operational procedures for soil protection (Responses **R**)

1. Processes influencing soil functions and soil quality

4. Factors (threats) influencing soil eco-services (Impacts **I**)



3. Ecological, technical, economic and social drivers of soil threats (Driving forces and Pressures, **D+P**)

2. Spatial and temporal changes of soil processes and parameters (State **S**)

CONCEPT FOR INTEGRATED RESEARCH IN ECOLOGY – EXAMPLE SOIL

	MAIN RESEARCH GOALS	PRIORITY RESEARCH AREAS	SCIENCES INVOLVED
1	To understand the main processes in the eco-subsystem soil; induced by threats	Processes influencing soil functions and soil quality	Inter-disciplinary research through co-operation of soil physics, soil chemistry, soil mineralogy and soil biology
2	To know where these processes occur and how they develop with time	Spatial and temporal changes of soil processes and parameters **(State S)**	Multi-disciplinary research through co-operation of soil sciences with - geographical sciences, - geo-statistics, - geo-information sciences (e.g. GIS)
3	To know the driving forces and pressures behind these processes, as related to policy and decision making on a local, regional or global basis.	Ecological, technical, economic and social drivers of soil threats **(Driving forces and Pressures, D+P)**	Multi-disciplinary research through co-operation of soil sciences with political sciences, social sciences, economic sciences, historical sciences, philosophical sciences and others
4	To know the impacts on the eco-services provided by the sub-system soil to other environmental compartments (eco-subsystems)	Factors (threats) influencing soil eco-services **(Impacts I)**	Multi-disciplinary research through co-operation of soil sciences with geological sciences, biological sciences, toxicological sciences, hydrological sciences, physio-geographical sciences, sedimentological sciences and others
5	To have operational tools (technologies) at one's disposal for the mitigation of threats and impacts	Strategies and operational procedures for soil protection **(Responses R)**	Multi-disciplinary research through co-operation of natural sciences with engineering sciences, technical sciences, physical sciences, mathematical sciences and others

W.E.H. Blum and J. Büsing, 2004

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OUTLOOK AND CONCLUSIONS

1. With the DPSIR approach it is possible to understand and to manage complex ecological/technical systems;

2. For the definition of indicators new research concepts are needed, including interdisciplinary and multidisciplinary approaches bringing together technical, ecological, cultural, social and economic sciences;

3. Indicators based on this approach can bridge between science and technology on one side and stakeholders, decision making and politics on the other side, thus sharing knowledge between those who have it and those who need it.