



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

SUSTAINABLE MANAGEMENT OF LAND AND SOIL MULTI-FUNCTIONALITY

by

Winfried E. H. Blum

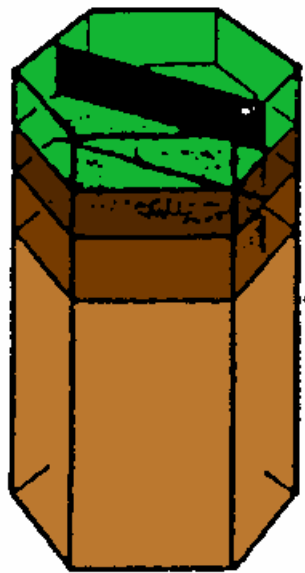
Institute of Soil Research, Department of Forest and Soil
Sciences, University of Natural Resources and Life Sciences
(BOKU), Vienna



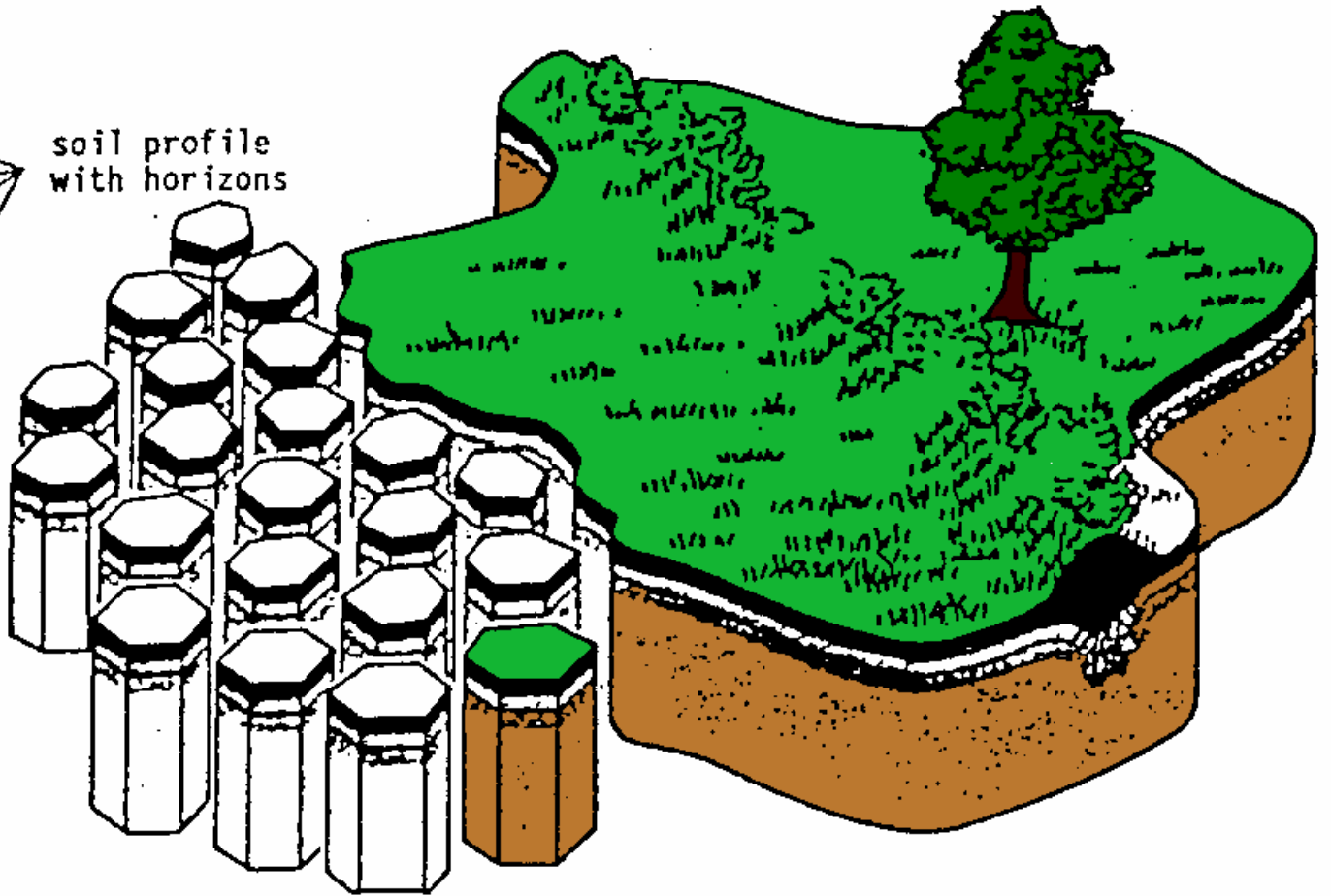
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1. MULTIFUNCTIONALITY OF LAND AND SOIL RESOURCES





soil profile
with horizons



3 ECOLOGICAL FUNCTIONS AND USES:

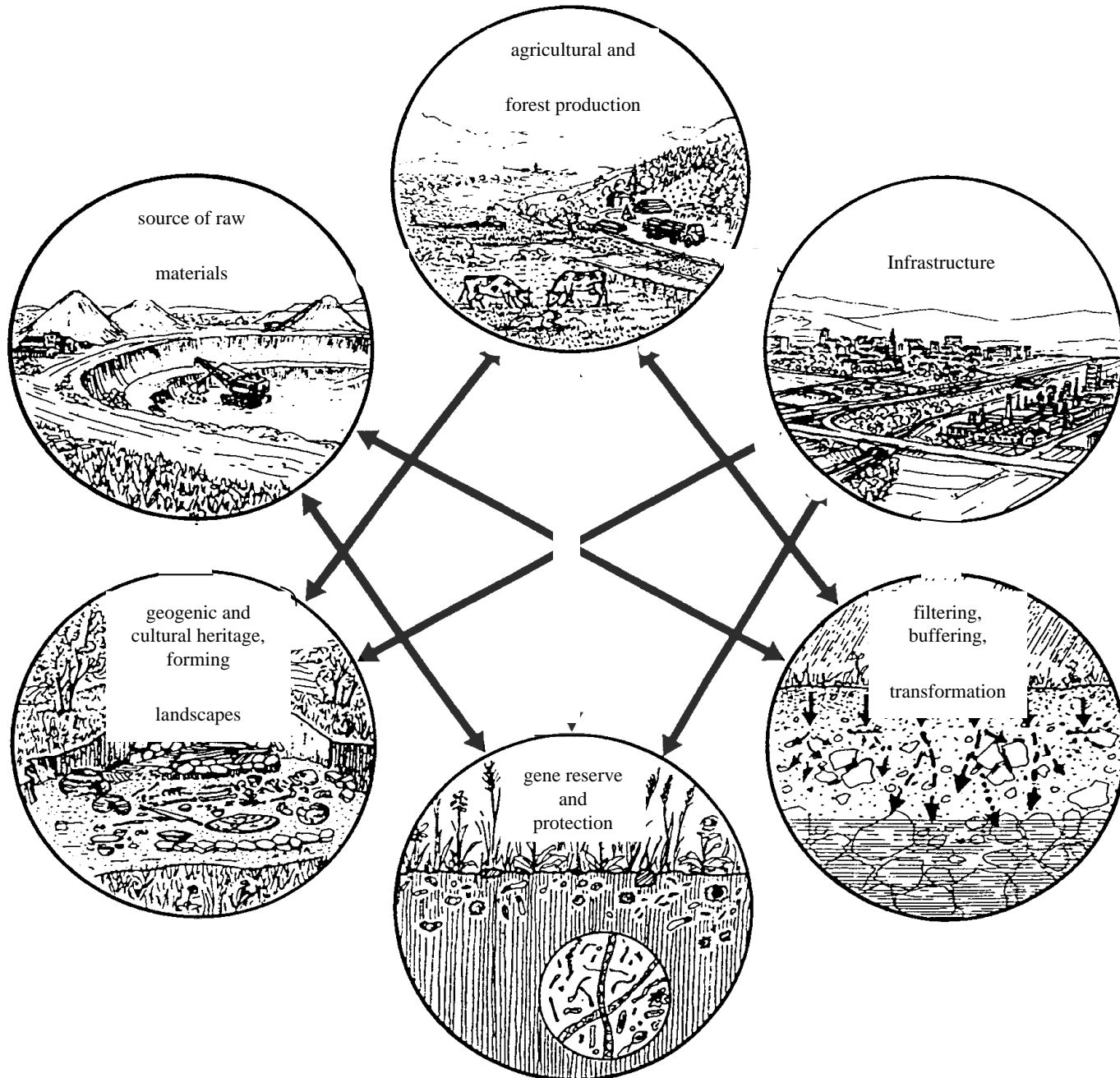
1. PRODUCTION OF BIOMASS, ensuring food, fodder, renewable energy and raw materials
2. FILTERING, BUFFERING, and TRANSFORMATION between atmosphere, groundwater and plant cover protecting the environment
3. BIOLOGICAL HABITAT AND GENE RESERVE



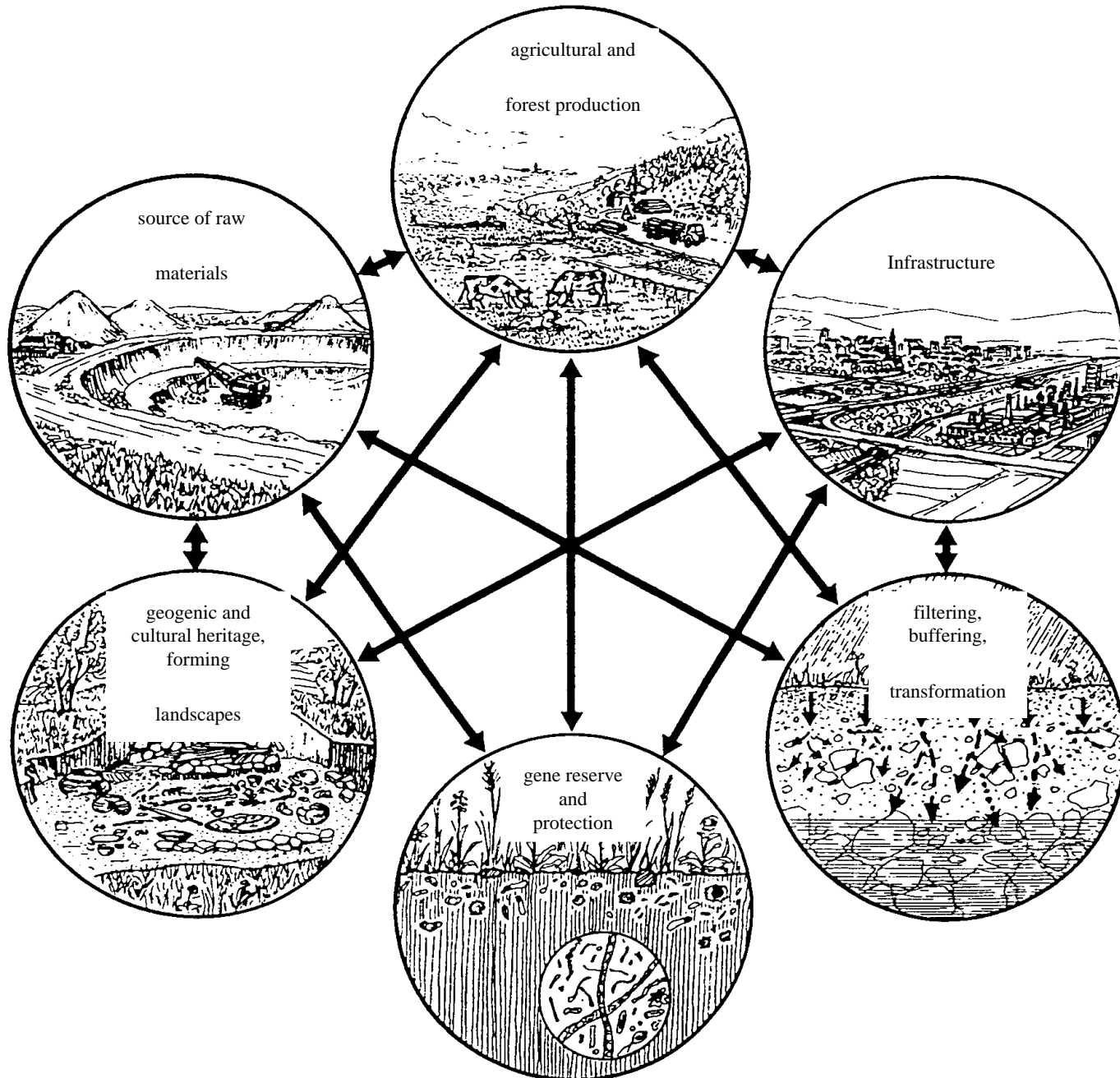
3 TECHNICAL, INDUSTRIAL AND SOCIO-ECONOMIC FUNCTIONS AND USES:

1. PHYSICAL 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 RAW MATERIALS, WATER AND GEOGENIC ENERGY
3. GEOGENIC AND CULTURAL HERITAGE, forming an essential part of the landscape and concealing aleontological and archaeological treasures

THE SIX MAIN USES OF LAND AND SOIL



COMPETITION BETWEEN THE 6 MAIN USES



2. COMPETITION BETWEEN THE SIX MAIN USES OF SOIL AND LAND



- 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.



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2.1 EXCLUSIVE COMPETITION



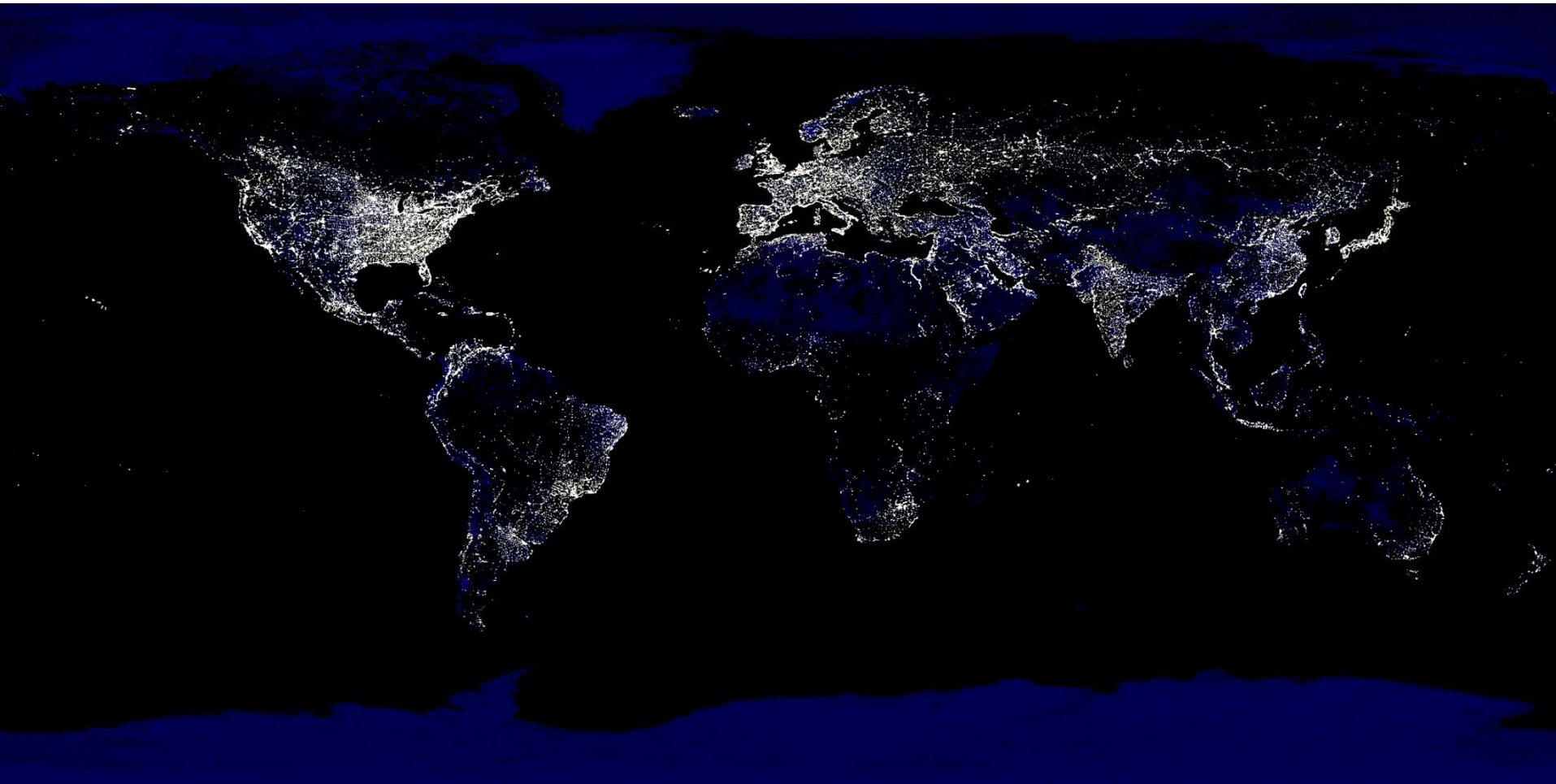




Fig. 1: European natural resources at day light



Fig. 2: Europe's built environment at night time



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2.2 INTENSIVE INTERACTIONS



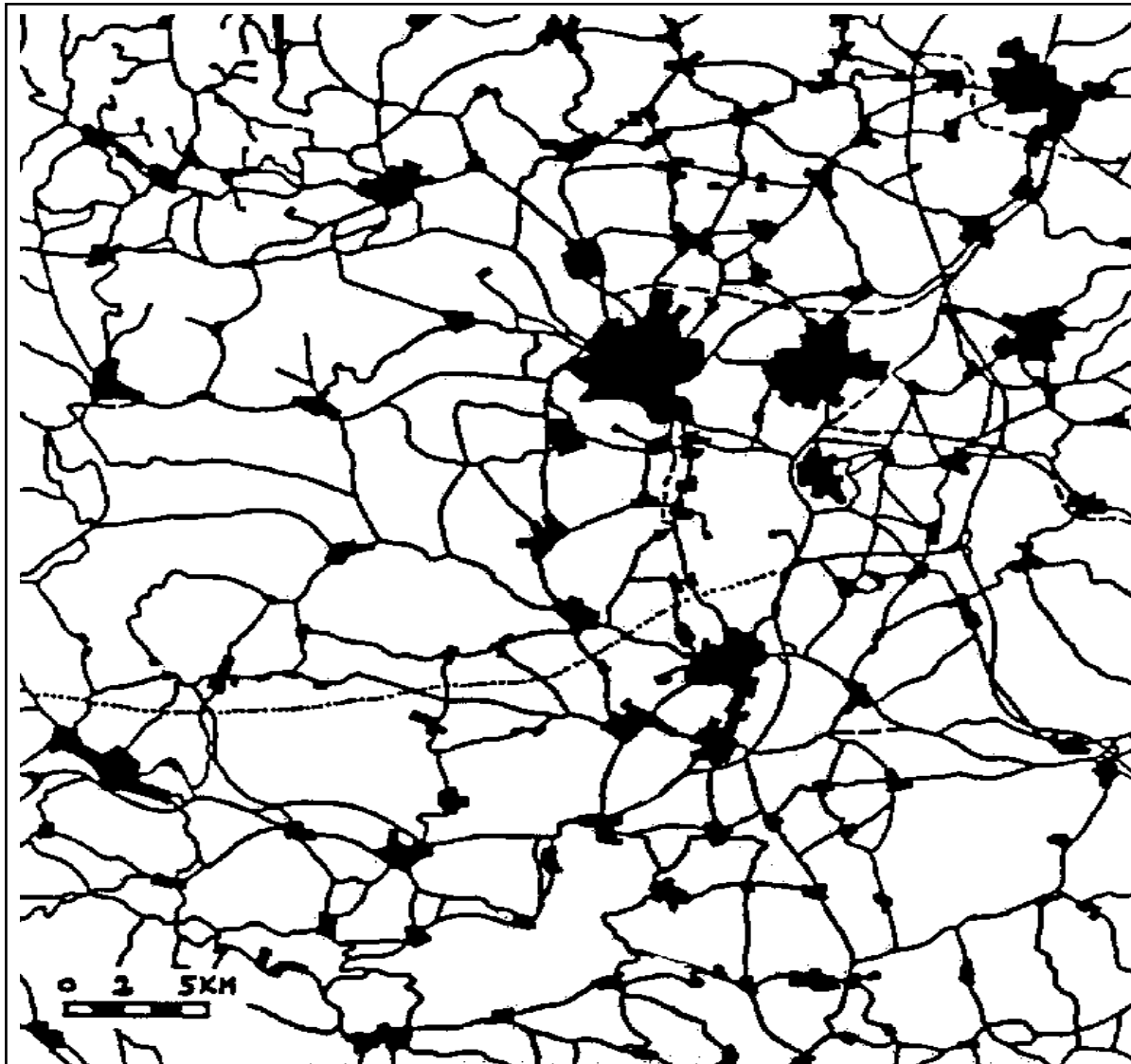
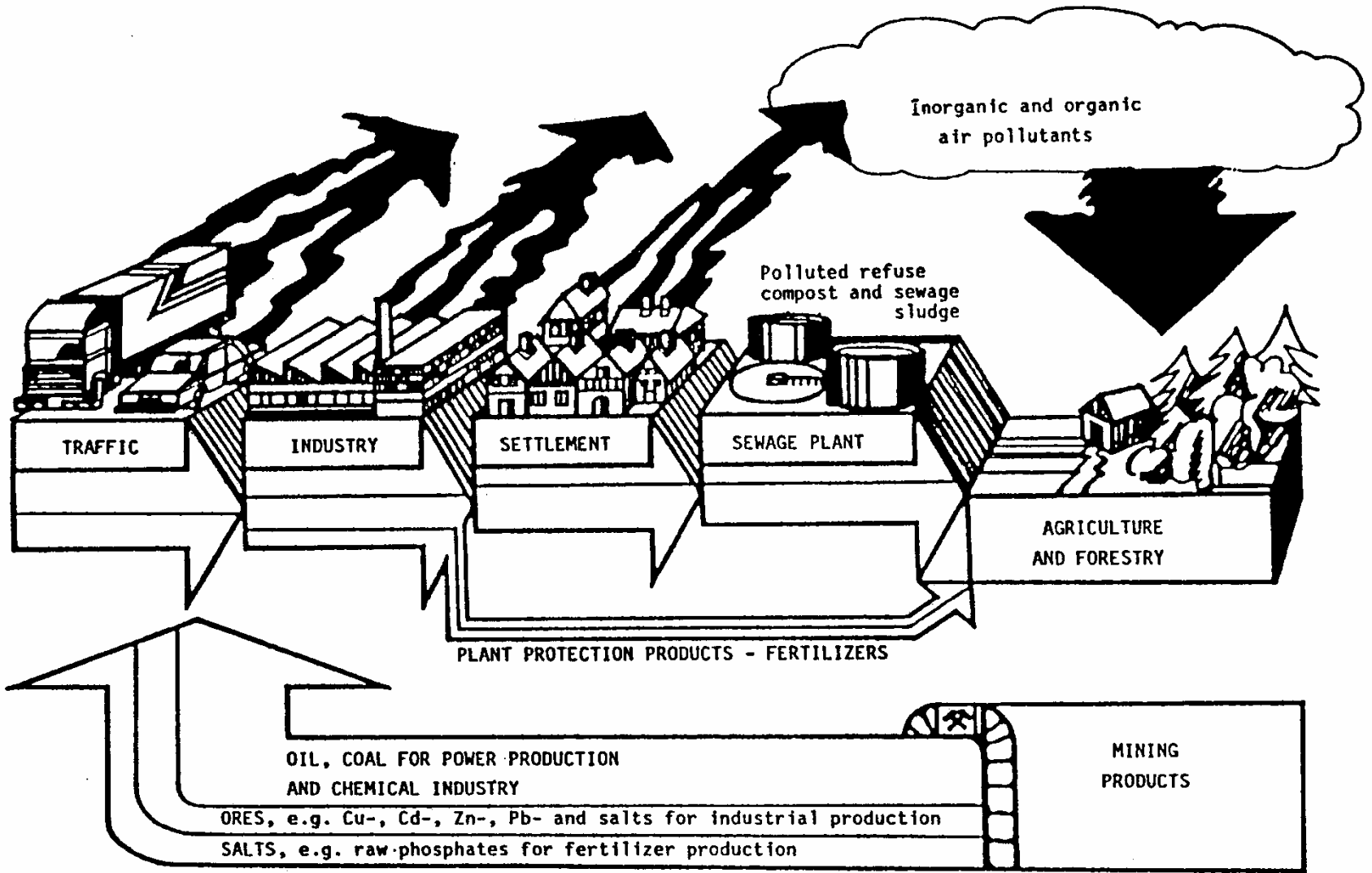
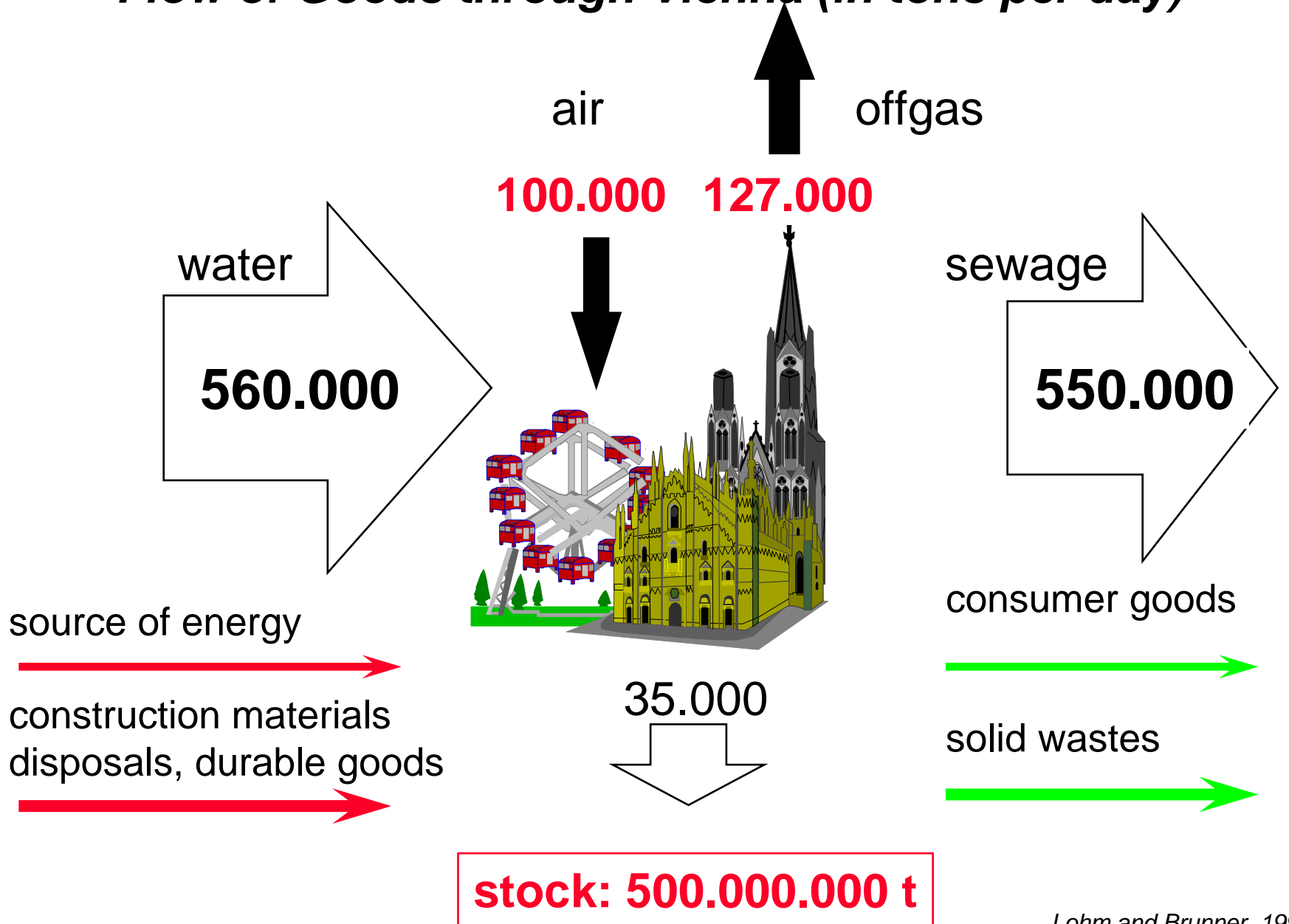


Fig. 4: Sealing of landscapes in south-western Germany
(observe scale of 5 km)

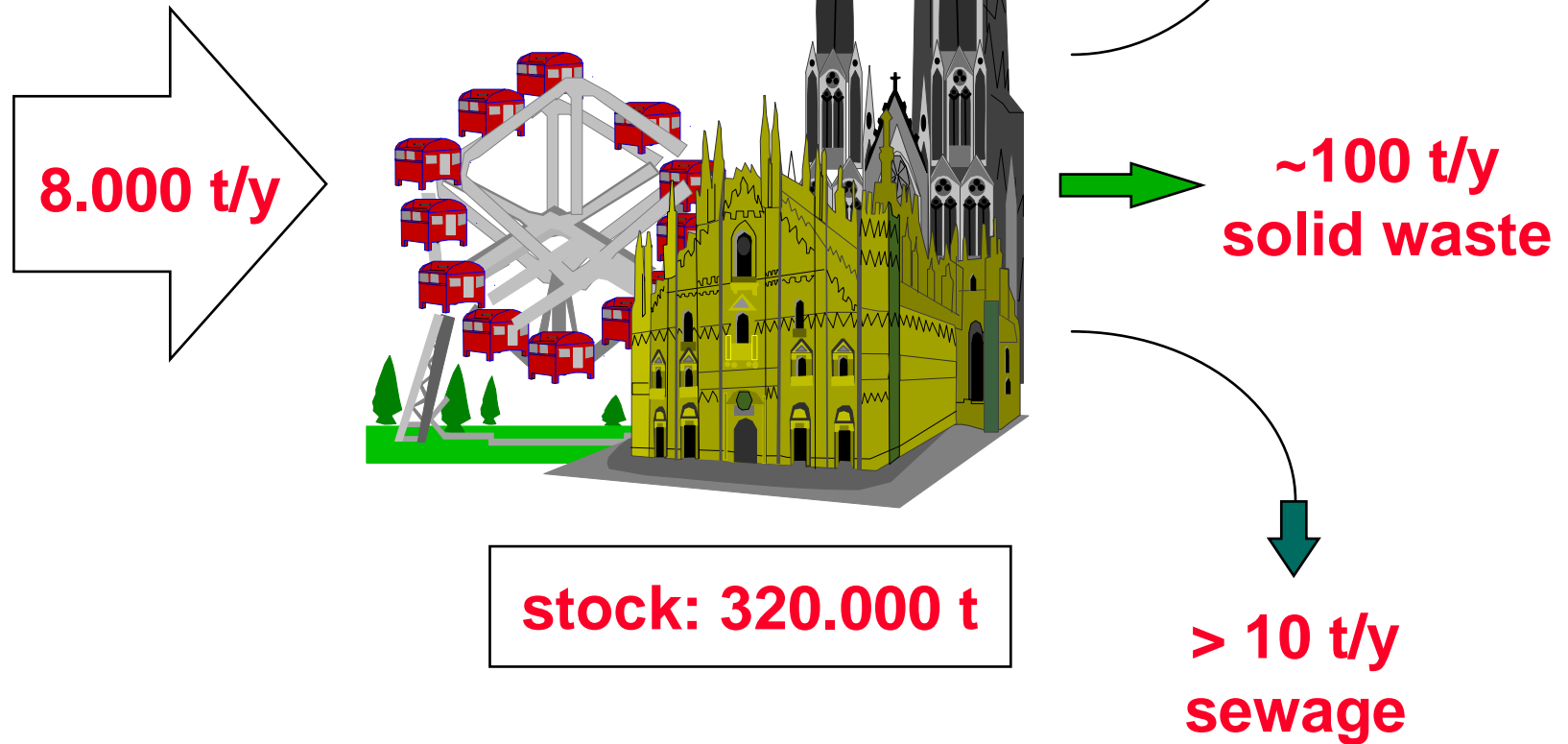


Soil pollution through excessive use of fossil energy and raw materials (Blum 1988)

Flow of Goods through Vienna (in tons per day)



Flow of Copper through a City (in tons per year)



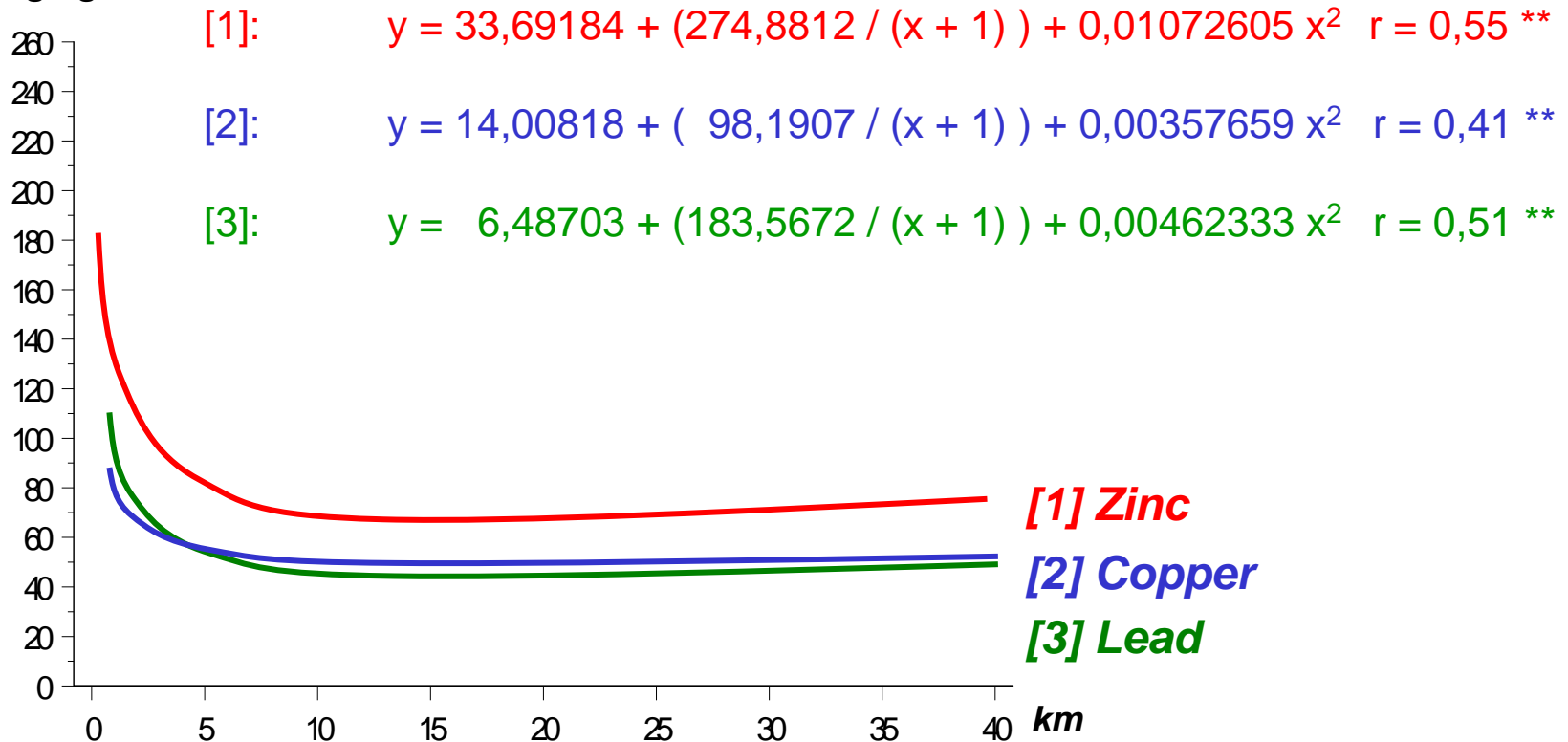


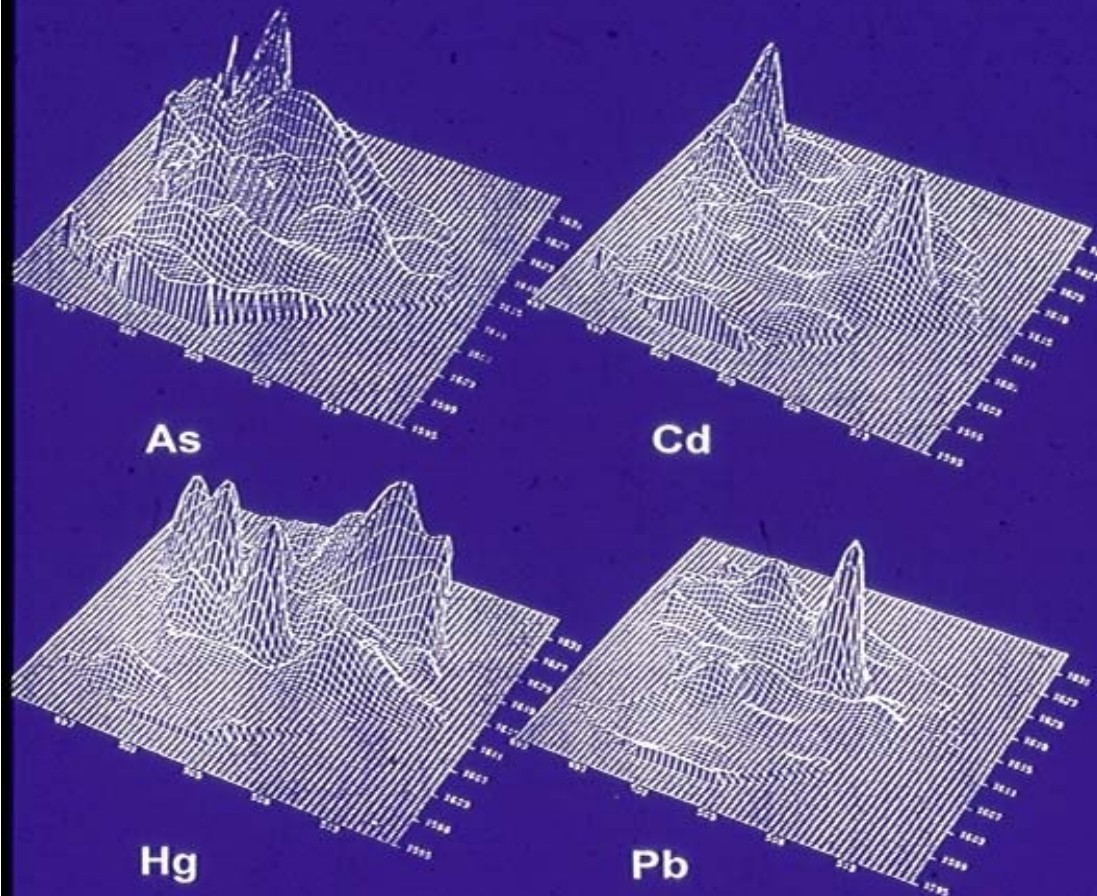
- sampling sites lower terrace
- ◆ sampling sites higher terrace

SAMPLING SITES (Koechl, 1988)

Changes of heavy metal content in tropsoils (0-20 cm) between metropolitan Vienna (Reichsbruecke) and the eastern state border (Koechl, 1988)

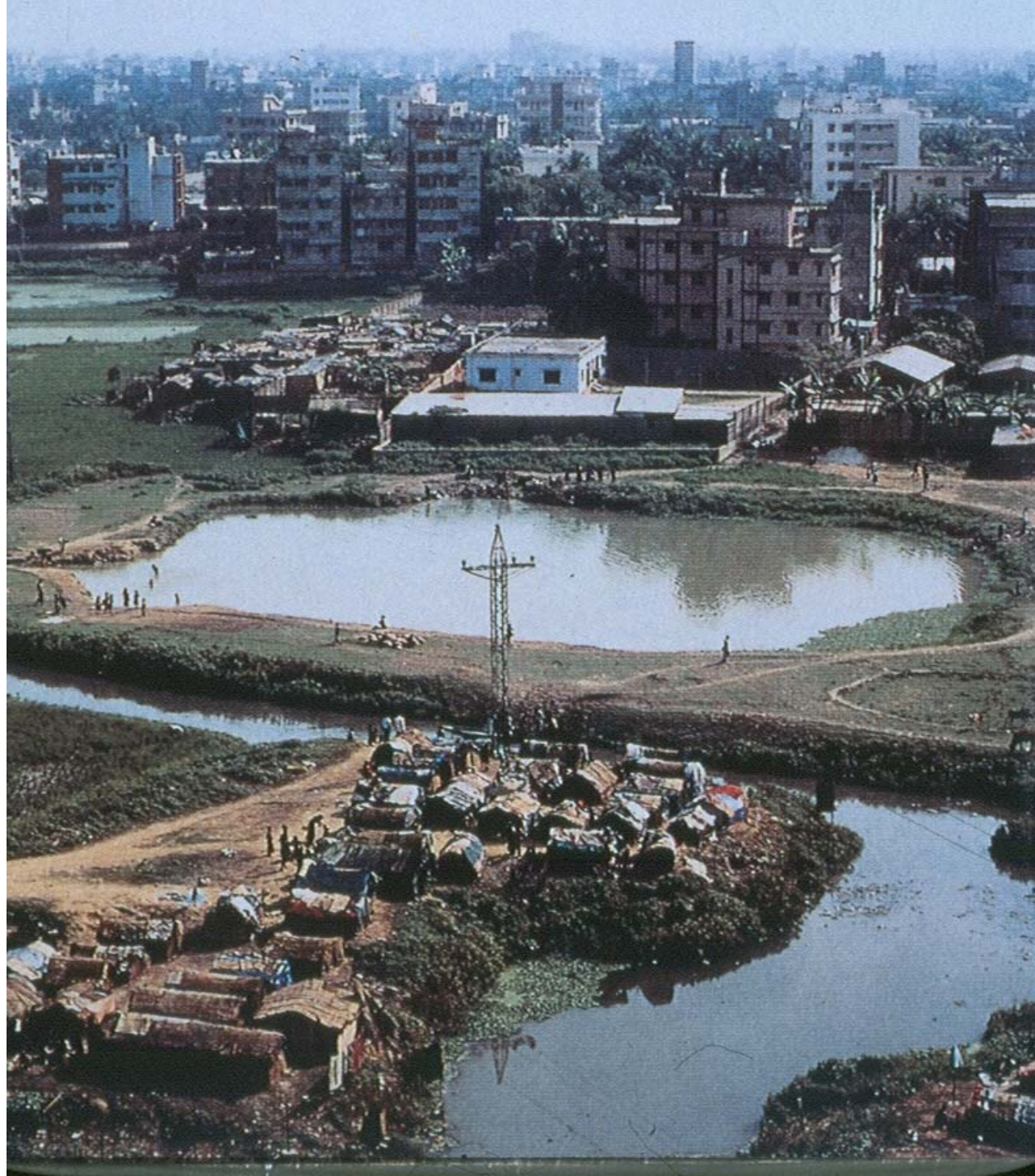
mg/kg soil





Distribution of As, Cd, Hg and Pb (mg/kg) in 373 topsoils (0-5 cm) of Metropolitan Manila (Manila, Caloocan, Quezon and Pasay)/Philippines (PFEIFFER et al., 1988)



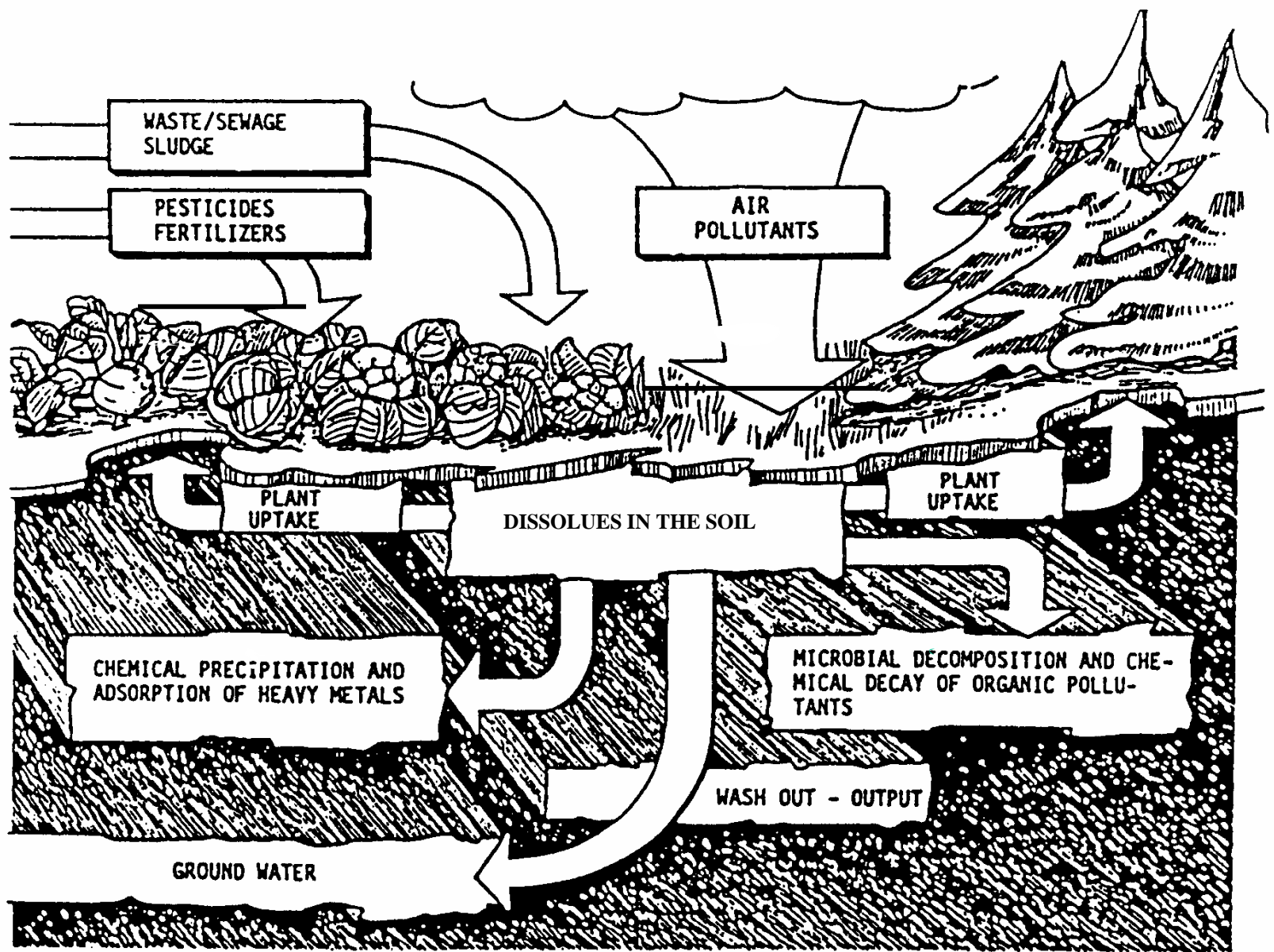




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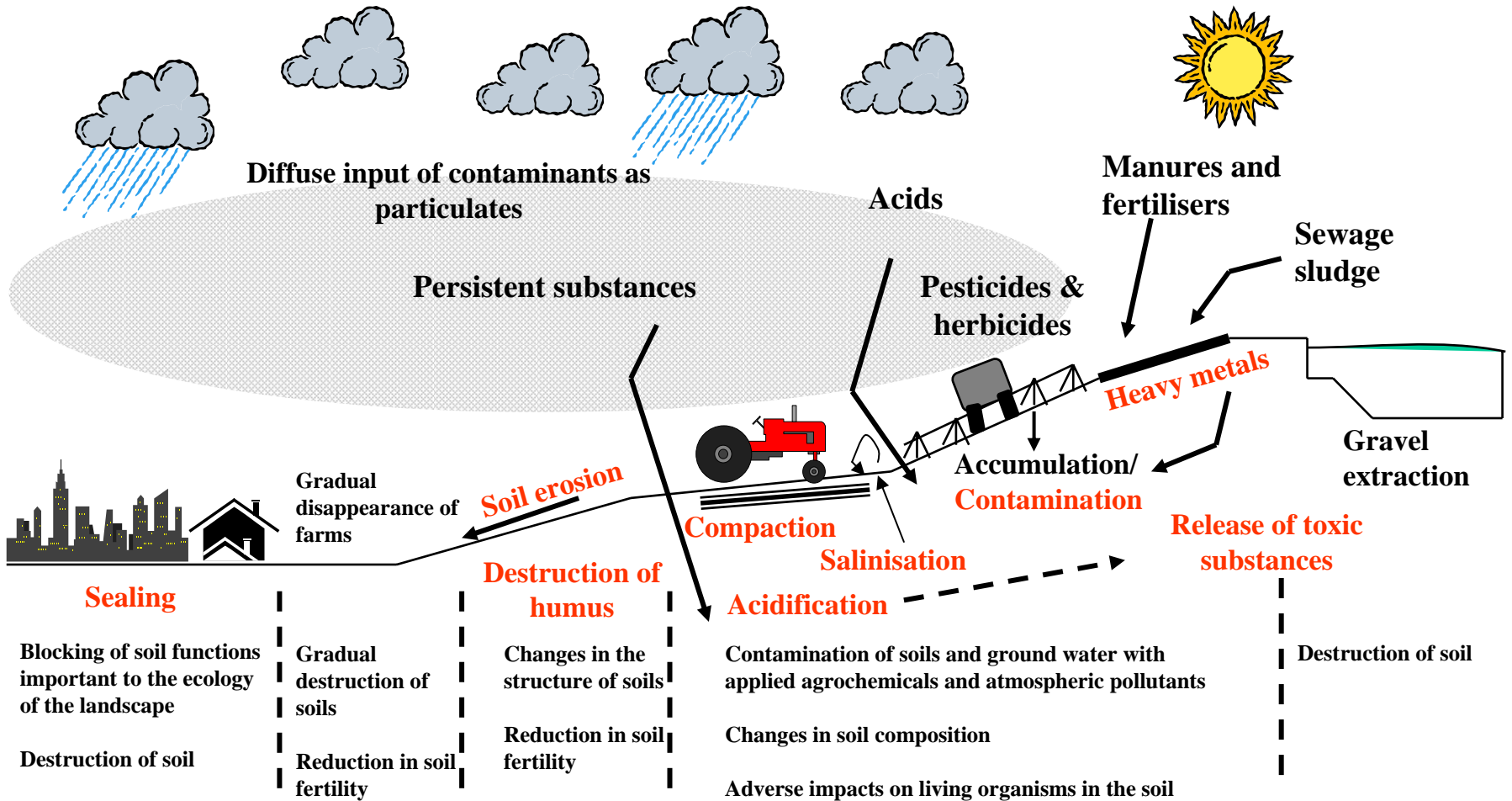
2.3 COMPETITION BETWEEN ECOLOGICAL USES





SOIL CONTAMINATION BY FERTILIZERS, SEWAGE SLUDGE AND PLANT PROTECTION PRODUCTS

The impact of human activities on soil



MAIN THREATS TO LAND AND SOIL

- 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 alcalinisation;
- Floods and land slides.



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3. CLASSIFICATION OF IMPACTS IN ORDER OF URGENCY

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 or salinisation;
- deep-reaching compaction.

2. REVERSIBLE*) DAMAGE/THREAT:

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

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



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4. DEFINITION OF SUSTAINABLE MANAGEMENT



Sustainable land use is the spatial and/or temporal harmonisation of all or prioritisation of specific land uses in a given area, avoiding or minimizing irreversible impacts.

This is not a scientific but a political issue, using top-down and bottom-up decisions.

Science can only develop scenarios using indicators for facilitating politics and decision making.



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5. MANAGEMENT OF MULTIFUNCTIONALITY THROUGH THE USE OF INDICATORS





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INDICATORS = INFORMATION
for understanding and managing complex systems.

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



INDICATORS FOR SUSTAINABLE LAND USE AND ENVIRONMENT PROTECTION

- **Direct and indirect ecological, technical, socio-economic and cultural indicators can be distinguished.**
- **Examples:**
 - **ecological:** soil quality, groundwater quality, biodiversity, human health
 - **technical:** access to the land, availability of tools
 - **socio-economic:** economic wealth, access to social resources
 - **cultural:** educational level



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

Human population
Land development
Tourism
Agricultural production
Transport
Industry/Energy
Mining
Natural events
Climate change
Water stress

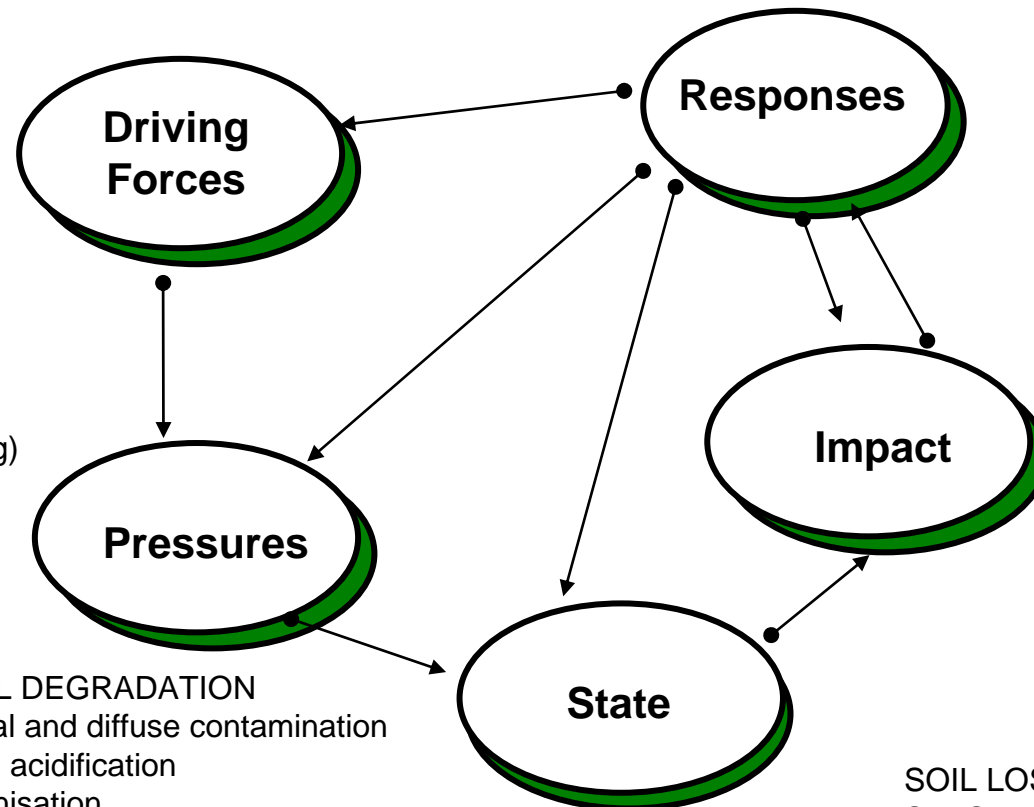
PRIMARY PROTECTION
Desertification Convention
Development of a national/
regional soil protection policy

SECONDARY PROTECTION
Reform of agricultural
programmes
Specific regulations or directives

Emission to air, water
and land
Urban expansion (soil sealing)
Infrastructure
Construction
De-forestation
Forest fires
Nutrient mining

SOIL DEGRADATION
Local and diffuse contamination
Soil acidification
Salinisation
Nutrient load (soil eutrophication) or
Nutrient depletion
Physical degradation
Biological degradation

SOIL LOSS
Soil Sealing
Soil erosion
Large scale land movements



INDIRECT (Effects on
other media)
Changes in population
size and distribution,
Loss of biodiversity,
Climate change,
Water stress

DIRECT
(Changes
in soil functions)



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

CONCEPT FOR INTEGRATED LAND MANAGEMENT

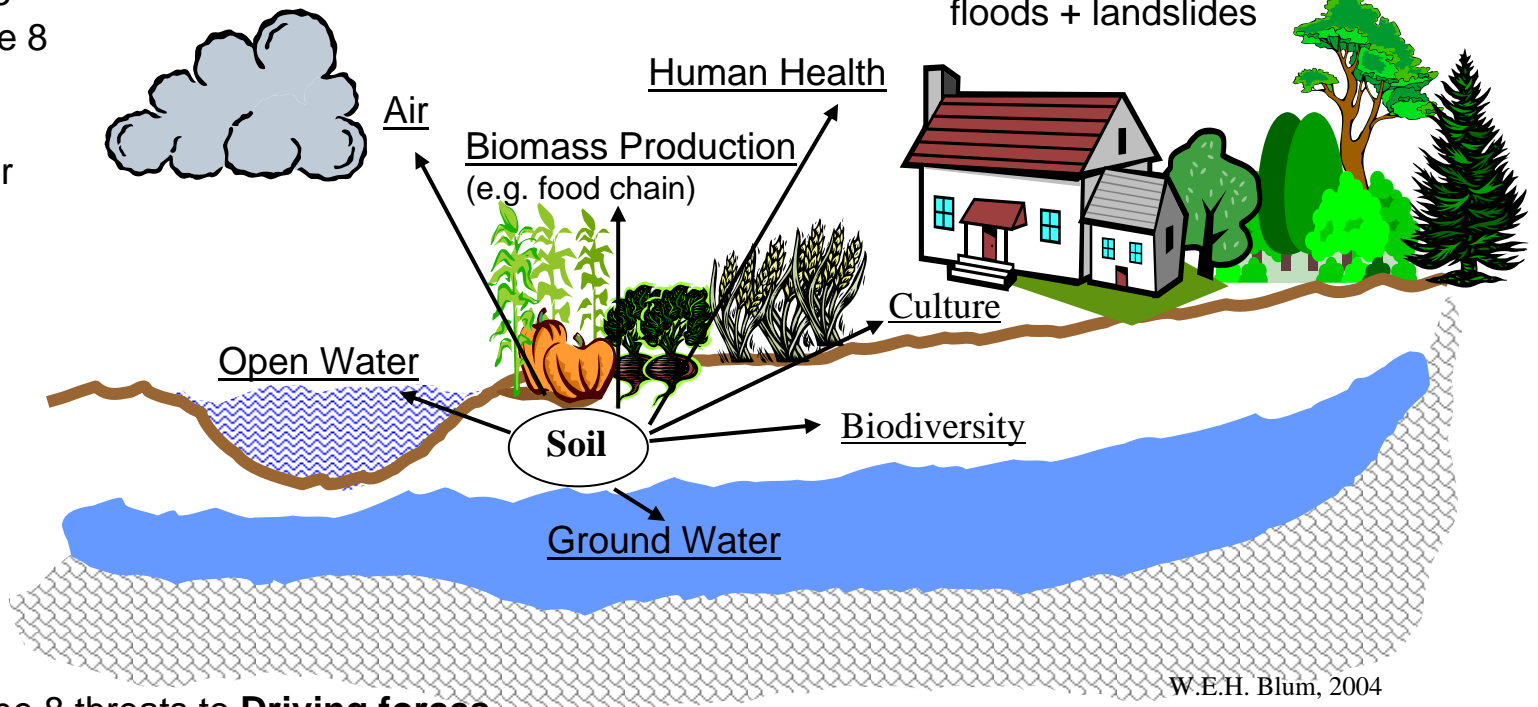
	MAIN LAND MANAGEMENT GOALS	OPERATIONAL APPROACHES (see Fig. enclosed)	SCIENCES INVOLVED
1	To understand the main processes in the eco-subsystem soil; induced by threats	Analysis of processes related to the 8 threats to soil and their interdependency: erosion, loss of organic matter, contamination, sealing, compaction, decline in biodiversity, salinisation, floods and landslides	Inter-disciplinary approach 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 approach 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 approach 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 approach through co-operation of soil sciences with geological sciences, biological sciences, toxicological sciences, hydrological sciences, physiogeographical sciences, sedimentological sciences and others
5	To have operational tools (technologies) for land management available	Development of operational procedures for the mitigation of the threats = Responses (R)	Multi-disciplinary approach through co-operation of natural sciences with engineering sciences, technical sciences, physical sciences, mathematical sciences and others

THE 5 MAIN OPERATIONAL STEPS

5. Definition of priorities and development of strategies and operational procedures for land management = **Responses (R)**

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

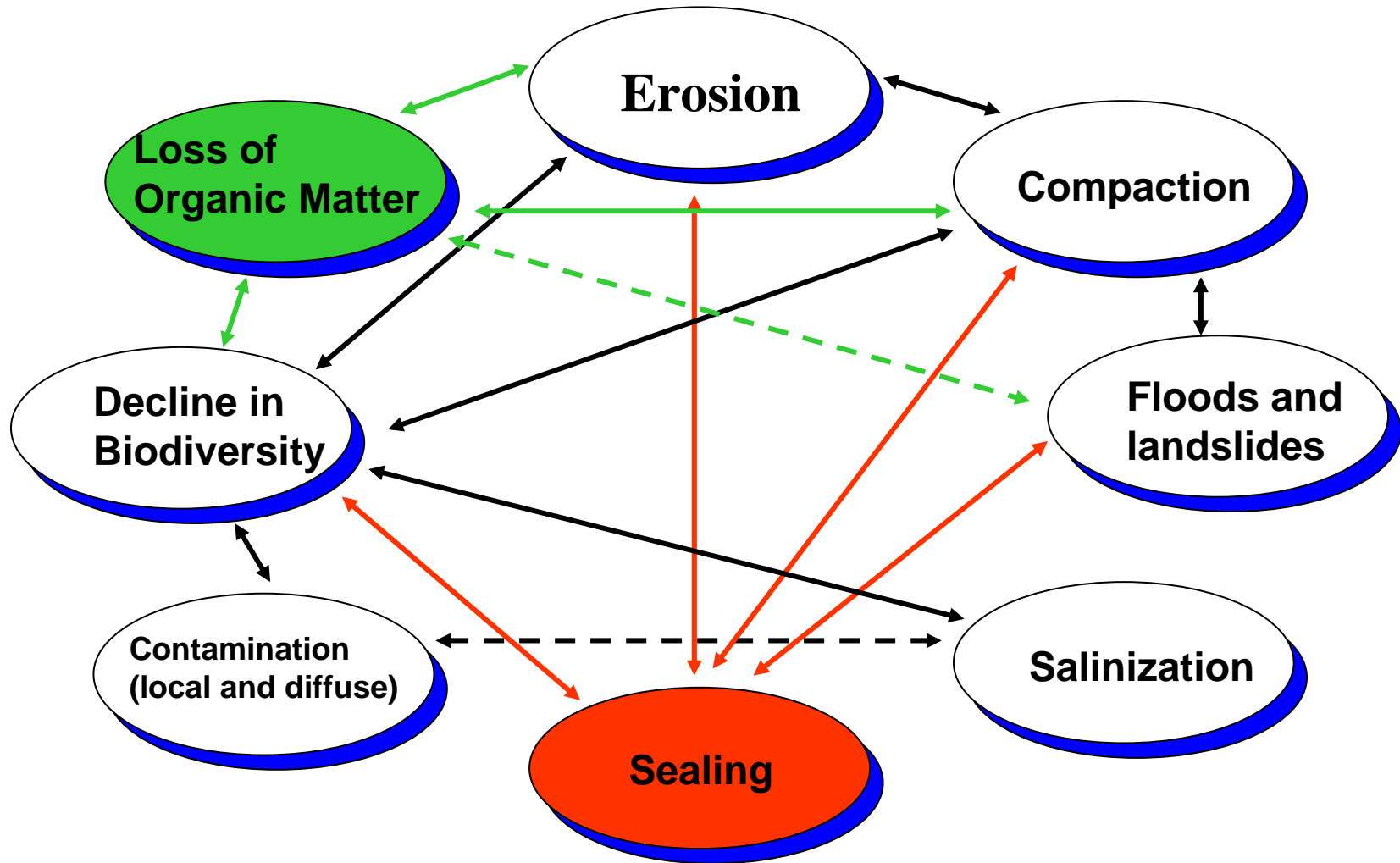


3. Relating the 8 threats to **Driving forces (D)** and **Pressures (P)** = Cross linking with cultural, social and economic drivers, such as regional policies (agriculture, transport, energy, environment etc.) as well as technical and ecological drivers, e.g. global and climate change

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**

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

THE 8 THREATS TO SOIL AND THEIR FUNCTIONAL INTERDEPENDENCIES

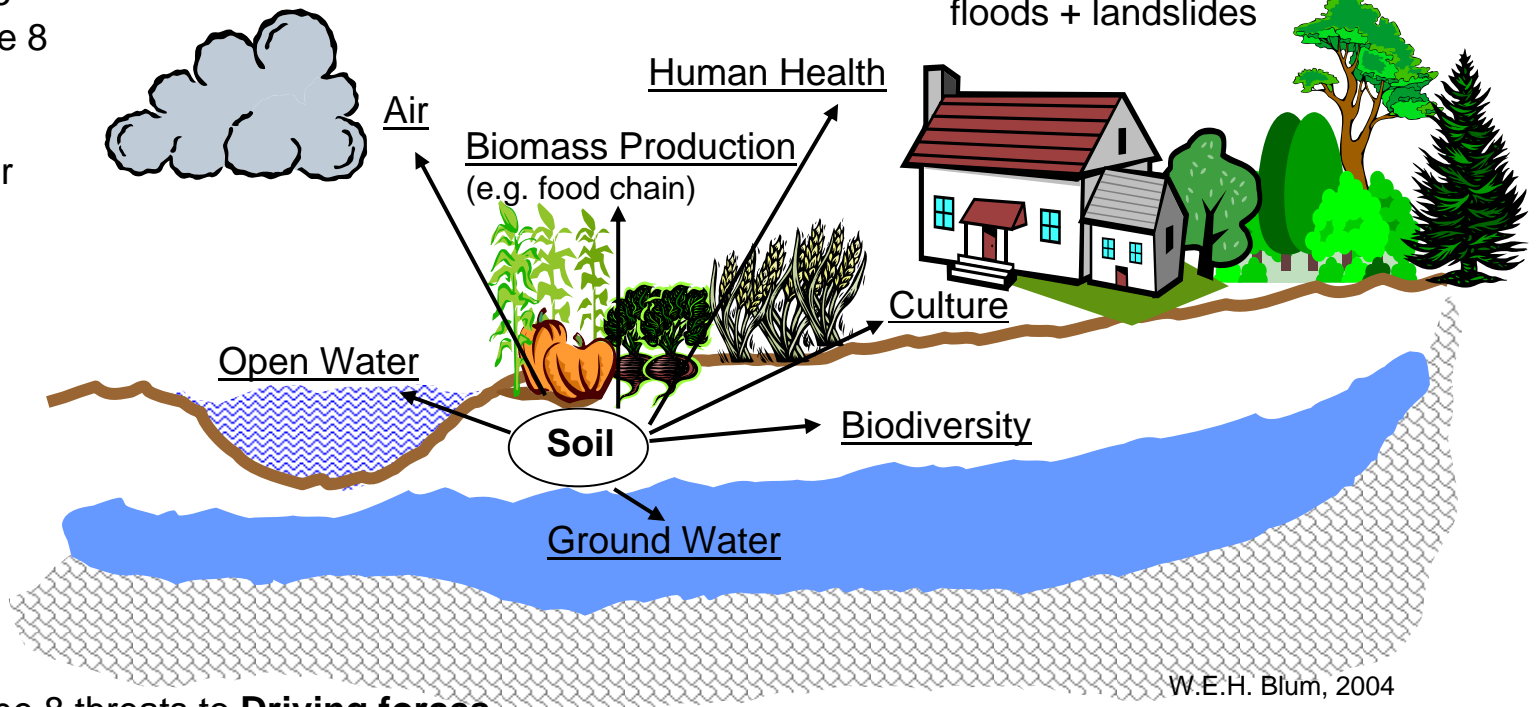


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3. ECOLOGICAL, TECHNICAL, ECONOMIC AND SOCIAL

DRIVERS OF SOIL THREATS (DRIVING FORCES AND PRESSURES, D+P)

THREATS:

erosion

organic matter

decline in biodiversity

compaction

salinisation

contamination (local and diffuse)

floods and landslides

sealing

LOCAL OR REGIONAL POLICIES:

agriculture

regional planning

environment

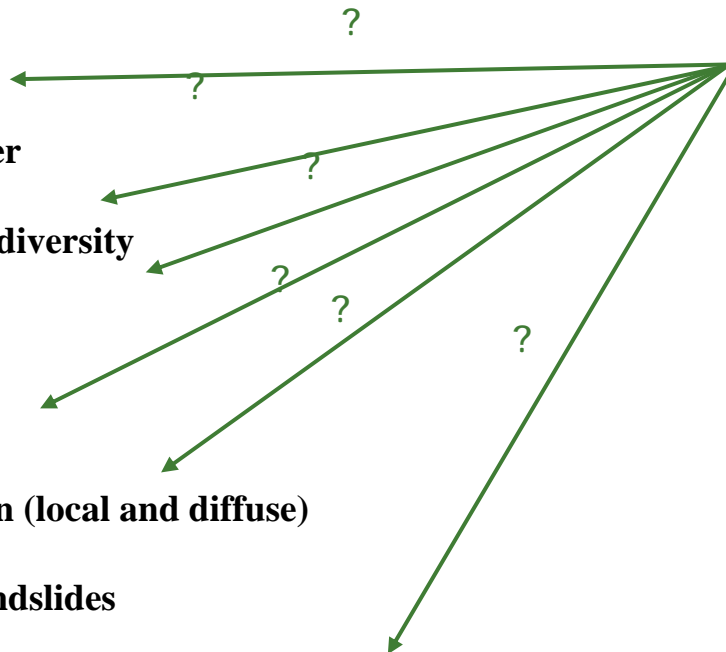
transport

energy

development

single market (competition)

others ...

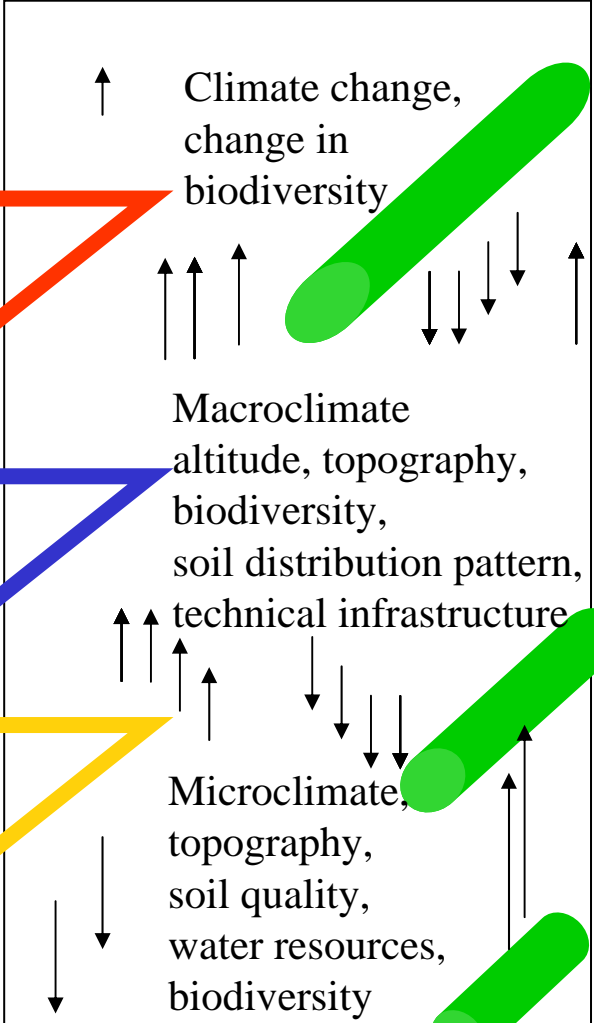
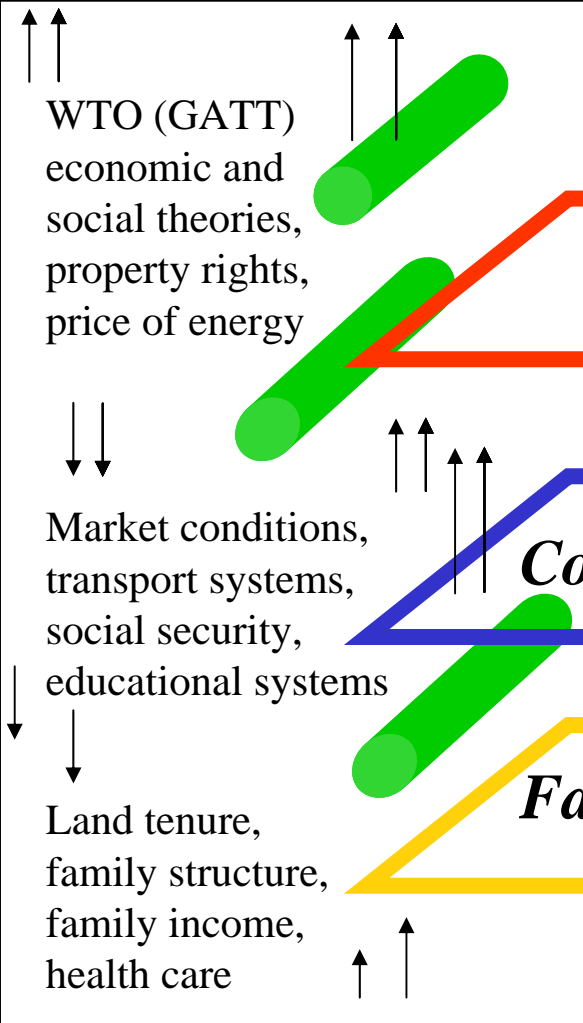


DRIVING FORCES OF LAND AND SOIL DEGRADATION - DIMENSIONS OF SPACE AND TIME

Cultural, Social and Economic Driving Forces

Ecological and Technical Driving Forces

DIMENSION OF SPACE



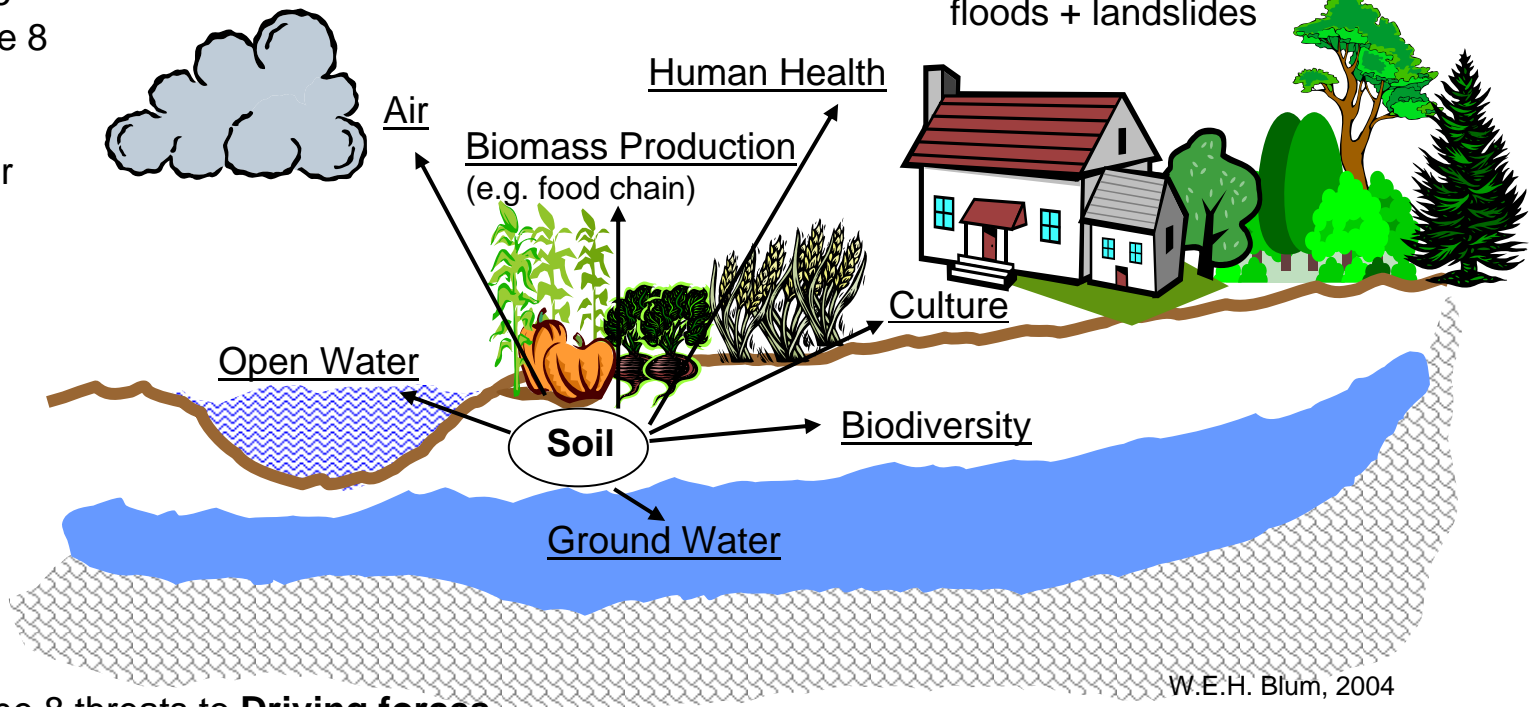
Short-, medium- and long-term temporal scales

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4. FACTORS (THREATS) INFLUENCING SOIL ECOSERVICES (IMPACTS I)

THREATS:

erosion

contamination

compaction

loss of organic matter

salinisation

floods and landslides

decline in biodiversity

ECOLOGICAL COMPARTMENTS SERVED BY SOIL:

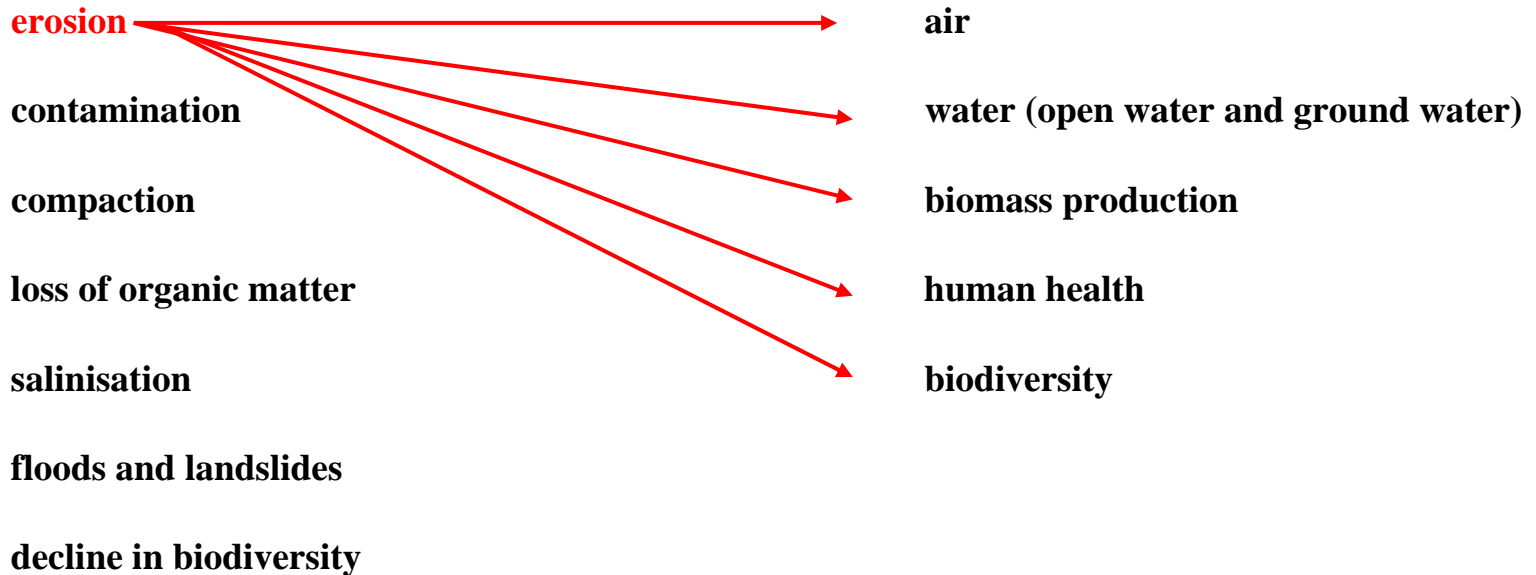
air

water (open water and ground water)

biomass production

human health

biodiversity

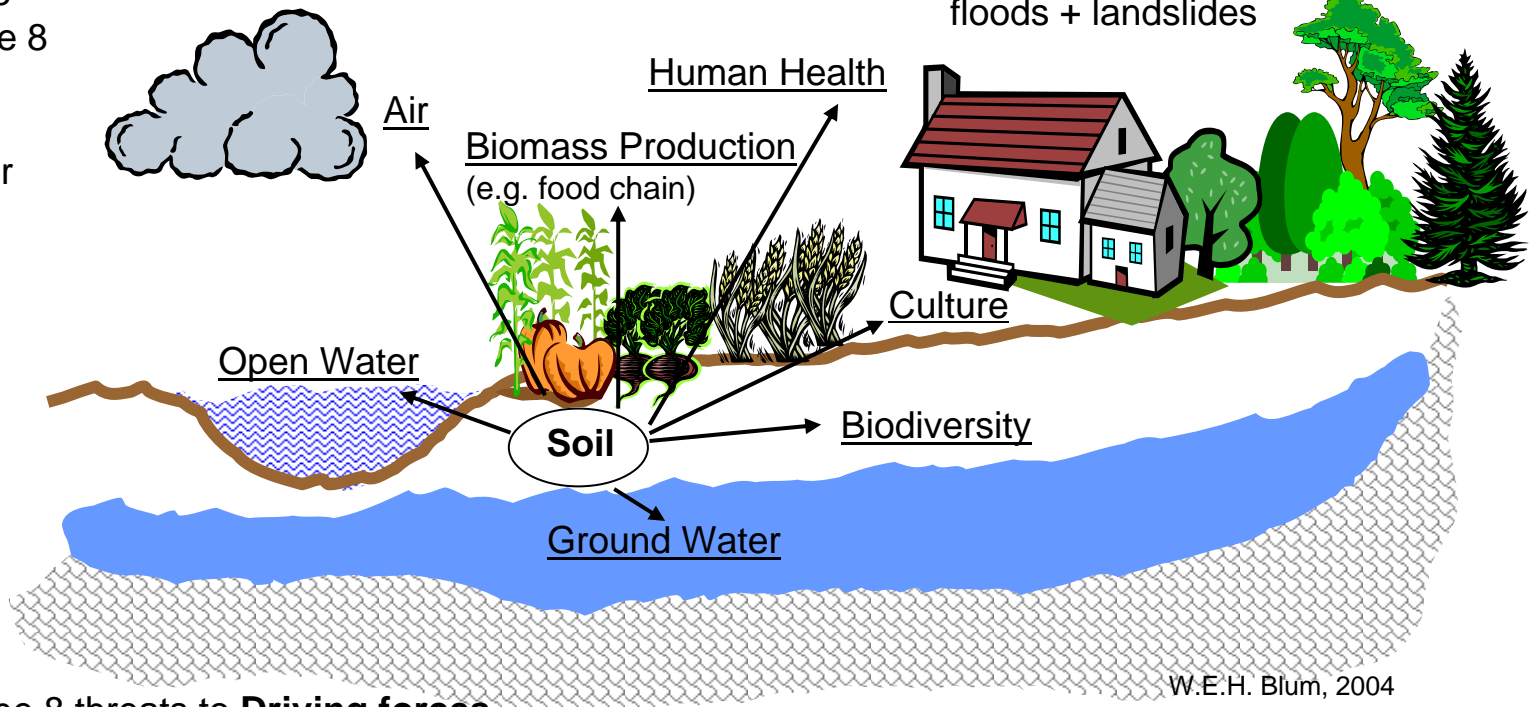


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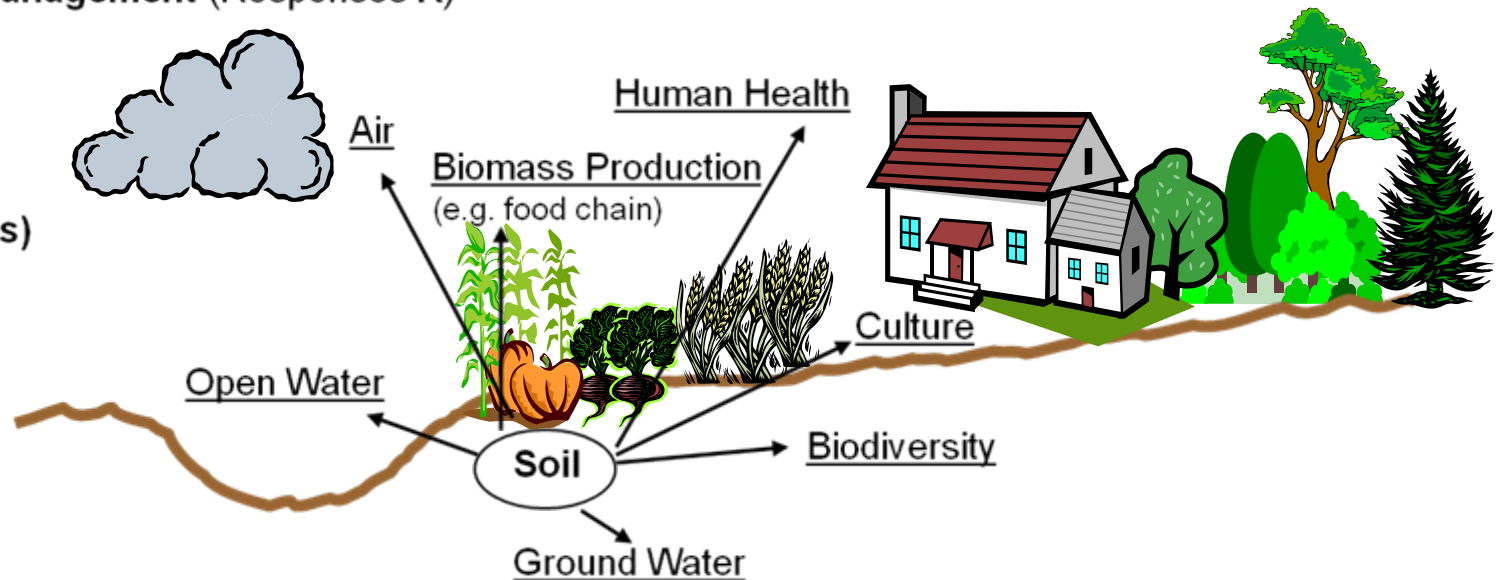
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PRIORITY AREAS FOR SOIL PROTECTION AND LAND MANAGEMENT BASED ON DPSIR

5. Definition of priorities, strategies and operational procedures for soil protection and land management (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)

W.E.H. Blum, 2004

CONCEPT FOR INTEGRATED LAND MANAGEMENT

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6. OUTLOOK AND CONCLUSIONS

1. With the DPSIR approach it is possible to understand and to manage land and soils;
2. Through the definition of indicators, the application of new management concepts is possible, including interdisciplinary and multidisciplinary approaches, bringing together technical, ecological, cultural, social and economic areas;
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.

THANK YOU FOR YOUR ATTENTION!

