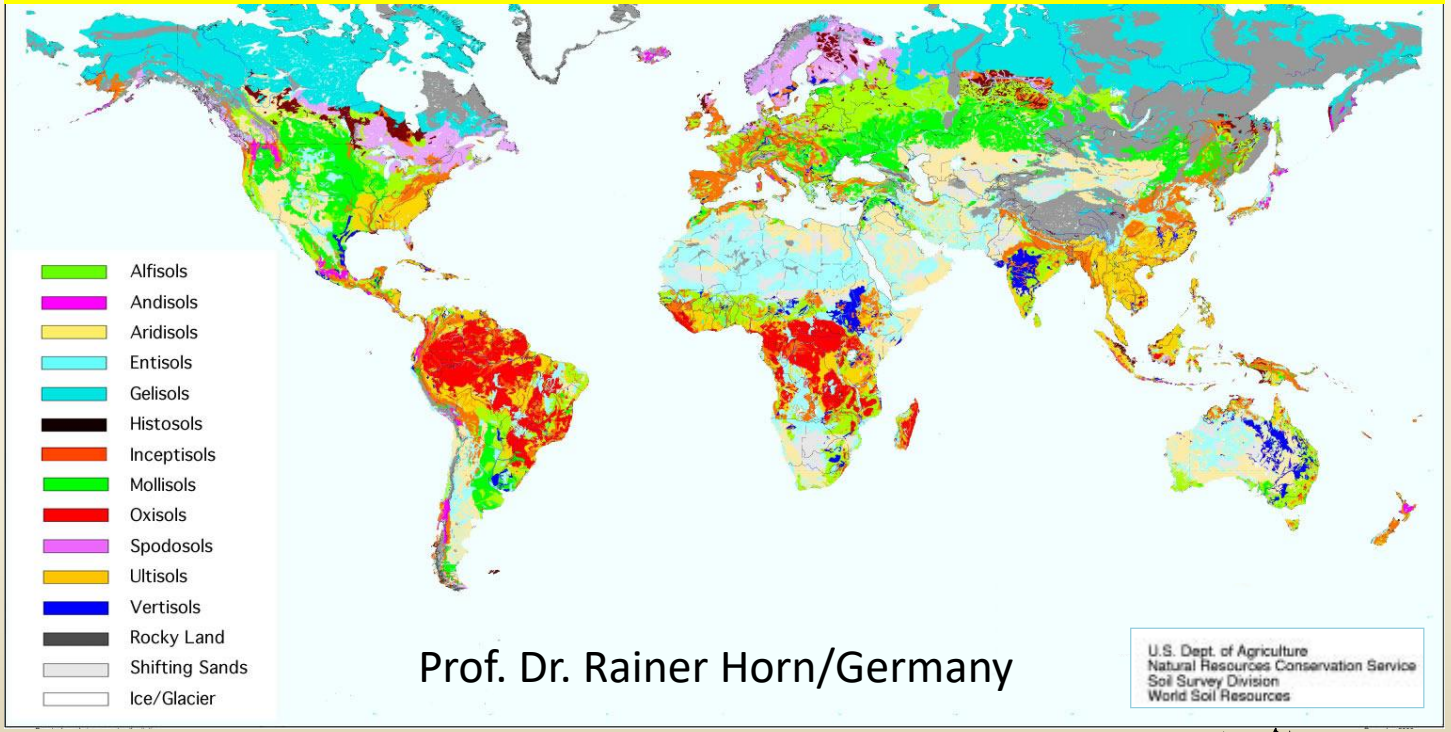
The IUSS
its role in the worldwide protection and management of soils



Prof. Dr. Rainer Horn/Germany

2015 International Year of Soils

Udongo · mulla · ithir · dirvožemio · tal · půdy · augsnes · 土壤 · พื้นดิน · sol · beheko · भूमि · terra · pôda · Boden · ভূমি · माटि · grond · ადგილზე · maaperän · talaj · maa · inhlabathi · suelo · አፈር · botten · dhulka ah · નમીન · ἔδαφος · приземен · tokës · solului · kásáa · ground · mặt bằng · ile · ùir · Zem · почва · mark · днище · toprak · मैदान · خاک · soil · つち · suolo · bodem · tla · الـ تربـ ه · zemlja · терен · मिट्टी · مٹی · зямля · tanah · jord · 토양 · 土 · yokutshuna · solo · धरती · gleba · அரிசி · மண்வெட்டி

Content

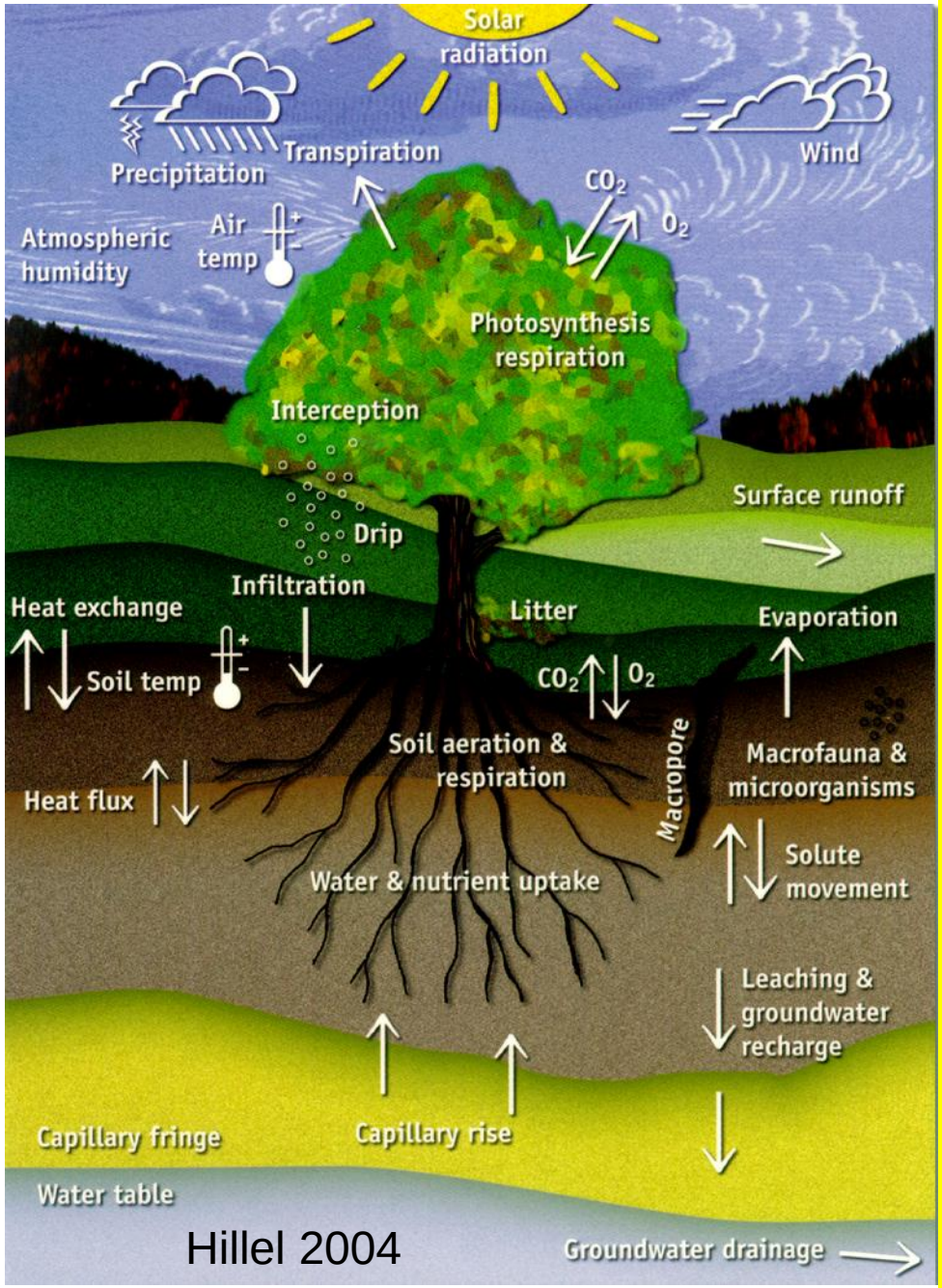
- **Some general remarks about Soils**
- **A few examples of soil sciences research approaches**
- **Insights in urgently needed soil research topics**
- Conclusions

Some general statements about soils

Soils serve a variety of functions:-

- **Biomass production** – agriculture, fibre, (only 11 % arable soils are without limitations), and wood based resources
- **Environmental interactions** – regulating the flow and filtering of substances from water, emitting and removing atmospheric gases
- A key component in the **Carbon Cycle and global change** but they are endangered by an intense degradation
- **Source and sink** for bioenergy and biowaste – soil and environment degradation due to deformation and following erosion
- Support of habitat and **biodiversity**
- Protection of **cultural heritage** and archaeology
- Providing **raw materials**

Soils are reactors



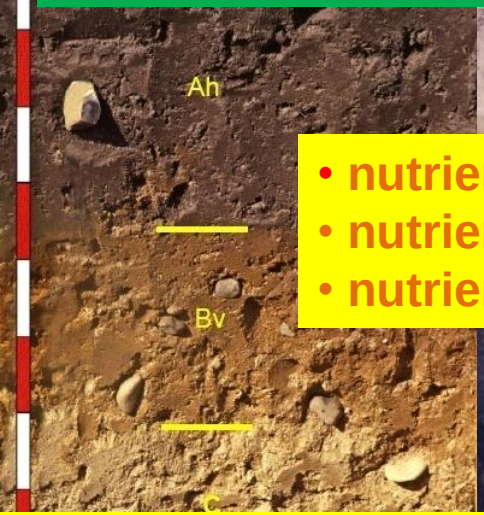
Hillel 2004

Soils are essential for food production

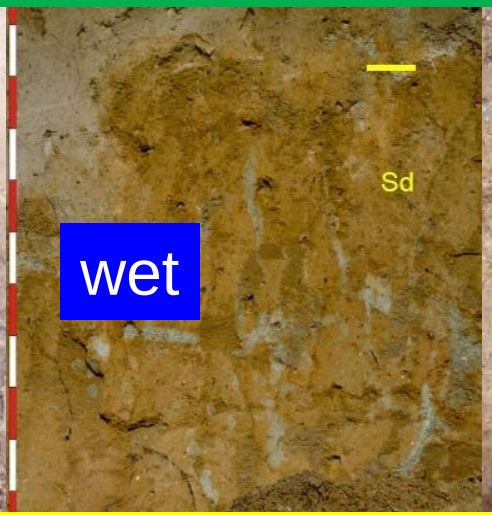
- 9 Billion people 2050
- >1 Billion people are starving already today
- +70 % food /2050
- 2,6 Bill. people live directly from agriculture, but 52% on degraded land
- + 300 km²/ day are irreversibly lost worldwide
- Vienna city is gone within 1,5 days!

- Sustainable development goals (SDG´s) for soils must be reached in time in order to perhaps maintain soil functions and adjust the management based on soil resilience demands.
- **Soil regeneration requires decades to centuries**

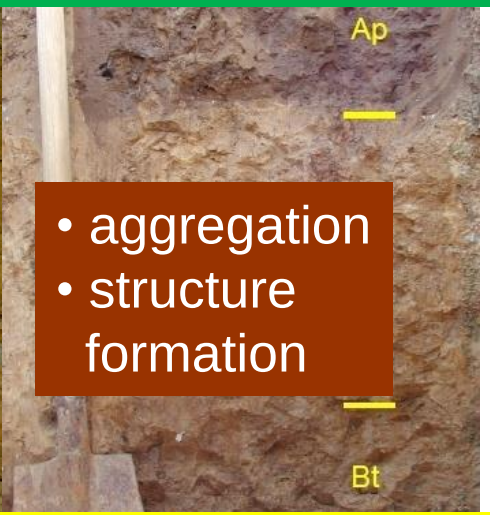
Soils are heterogenous (examples from Europe)



- nutrient storage
- nutrient availability
- nutrient translocation



wet



- aggregation
- structure formation

Soils have defined but only limited properties and functions. They are sensitive and can be irreversibly degraded if land use is not adjusted to soil properties.

Redox reactions

wet

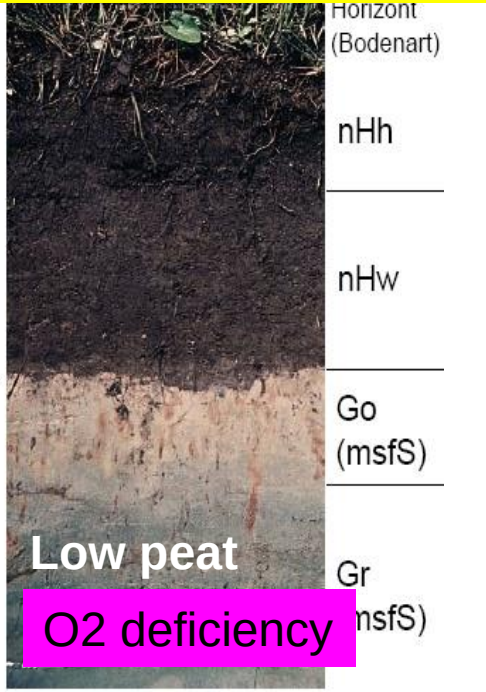
Gleysol

O2 deficiency

dry

Podzol

Kolluvisol



Low peat

O2 deficiency

Land Area (million km²) in Land Quality Classes with Estimated Population (millions) in Each Class

Land Quality Class	Area Million km²	Area %	Population Millions	Population %
I	3.06	2.38	424	5.9
II	6.40	4.98	993	13.8
III	5.85	4.55	331	4.6
IV	5.08	3.95	820	11.4
V	21.23	16.51	2073	28.8
VI	17.13	13.32	850	11.8
VII	11.58	9.01	797	11.1
VIII	21.46	16.69	128	1.8
IX	36.78	28.61	784	10.9

Source: Blum and Eswaran, 2004, modified

Examples for soil types

Mollisols, Alfisols , Ultisols

Entisols, Inceptisols Vertisols

Oxisols, Spodosol, Glacier, rocky land

11,9%

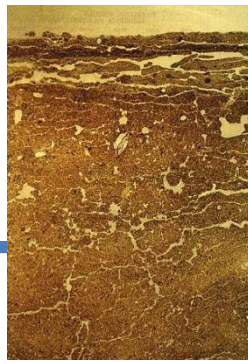
24.3 %

33,8%

52%

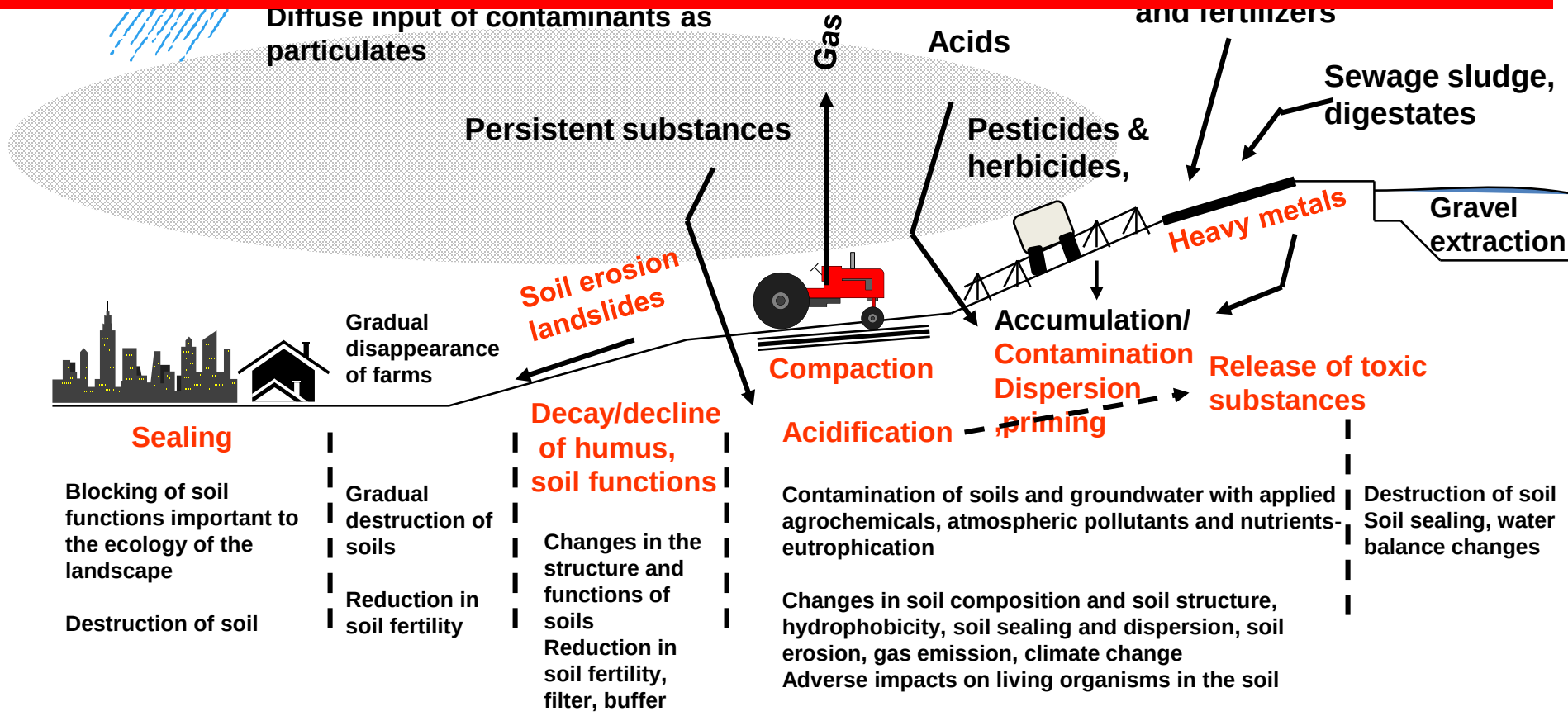
54,3%

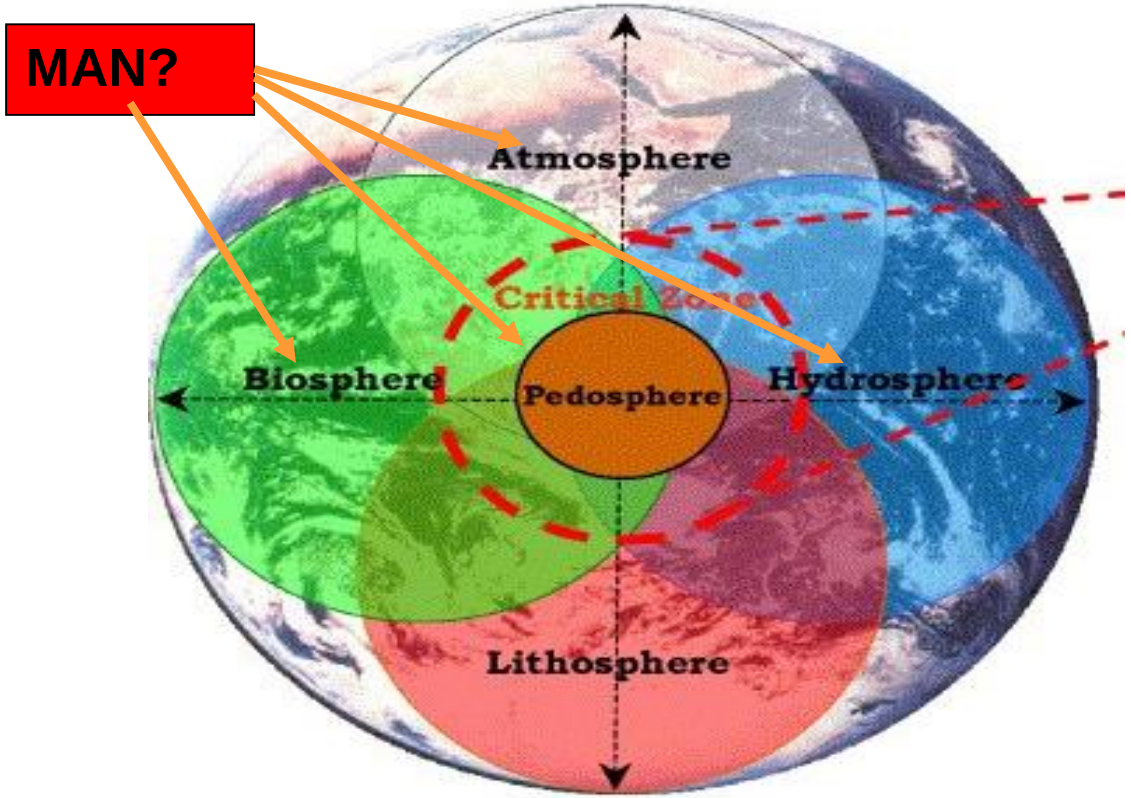
23.8%



Although we know negative and often irreversible impacts of continuous human activities on soil properties and functions…..

We must define the relevance and consequences under various climatic, hydraulic conditions and for various landuse systems to avoid further degradation but maintain soil performance and resilience



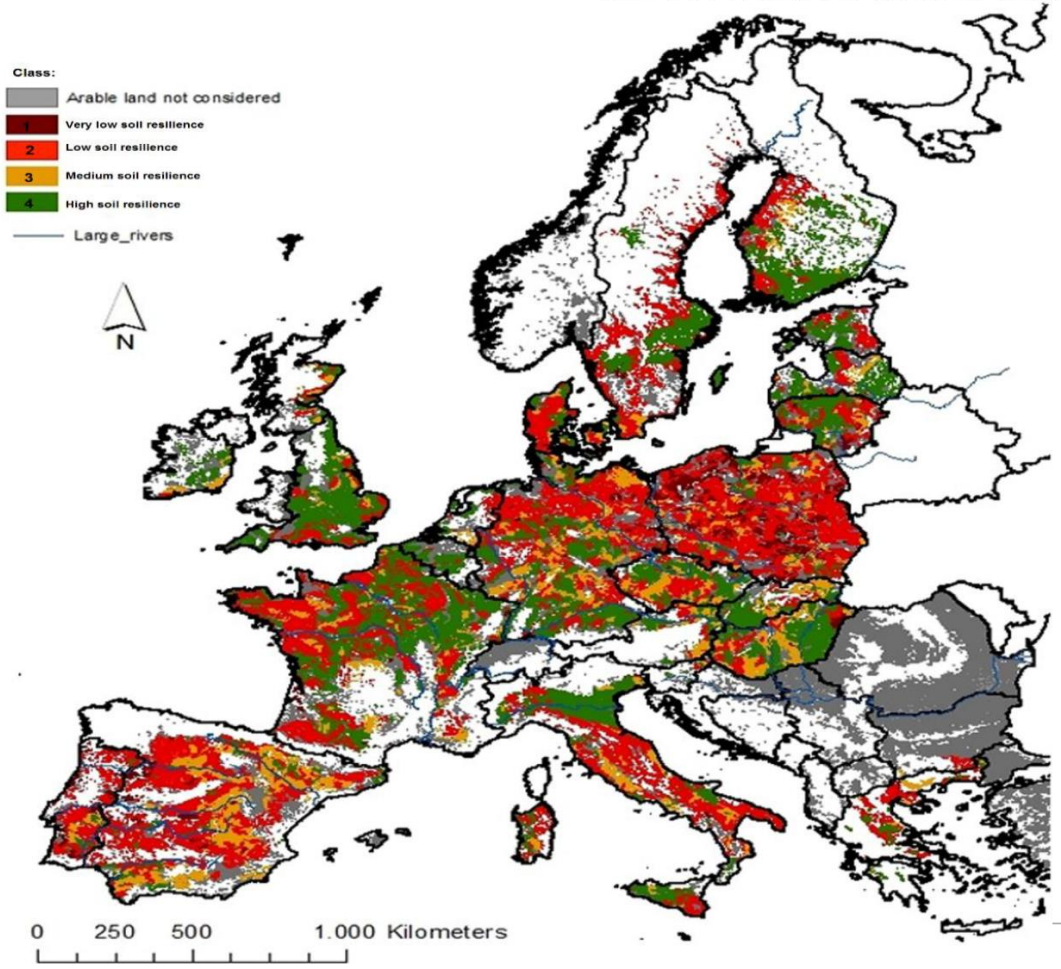


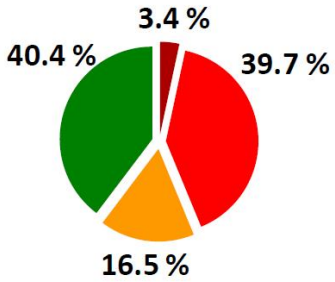
A few examples of soil sciences research approaches:

We have to quantify soil functions on **local and global scale** based on existing soil map information

The potential of sustainable intensification of food production in Europe based on the natural resilience and performance of soils

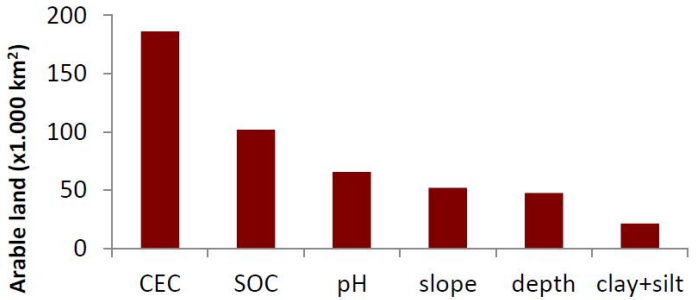
CONTINENTAL SCALE- EU 25





- Very low soil resilience and performance
- Low soil resilience and performance
- Medium soil resilience and performance
- High soil resilience and performance

Limiting indicators on analyzed land:



Analysed arable land: 671,672 km2

Schiefer et al. 2018

Soil Processes are always coupled at all scales– the link between physical, chemical and biological processes

Microbiological processes

Soil mechanical processes

undrained
elasto-plastic, hysteretic
non-linear
water suction dependent

viscoelastic

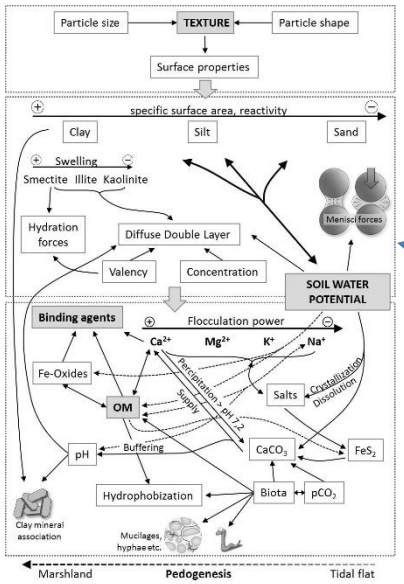
Mechanics

Hydraulic components

rigidity of pore systems
pore pressure
swelling, shrinkage

Mechanical components

crit. state soil mechanics
effective stress
total stress



Physico-chemical processes

Water fluxes

water, *suspension*, heat
non-linear, hysteretic
pore water pressure (pwp),
hydraulic potential

physicochemical properties,
viscosity, surface tension

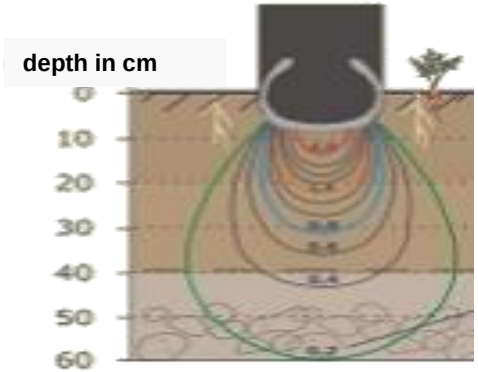
Hydrology

Richards et al 2000

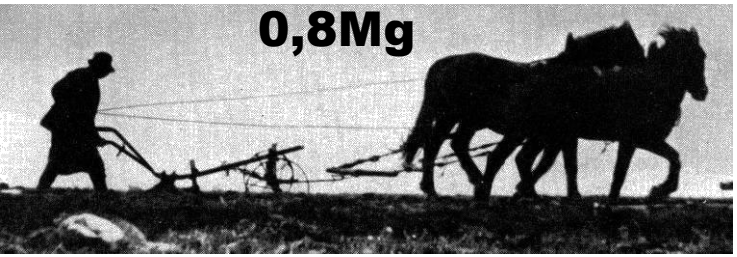
We know and need to react: Development of the mechanical stress input in agriculture and forestry - anthropogenic effects

Increased area requires more powerful machinery

Enhanced stress intake and depth distribution



3,5Mg



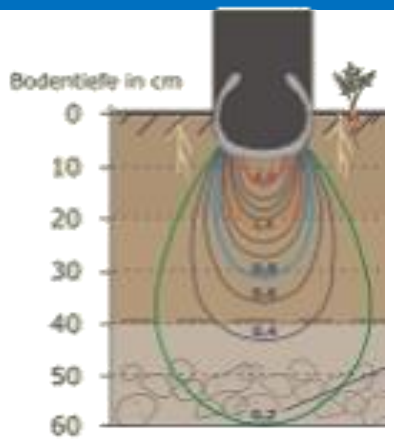
around 1900

about 1960

today

future?

We see what happens when internal soil strength is exceeded: Physical soil degradation processes



Stress propagation in the subsoil

Changes of physical soil functions

• structure deterioration

Consequences for ecological properties

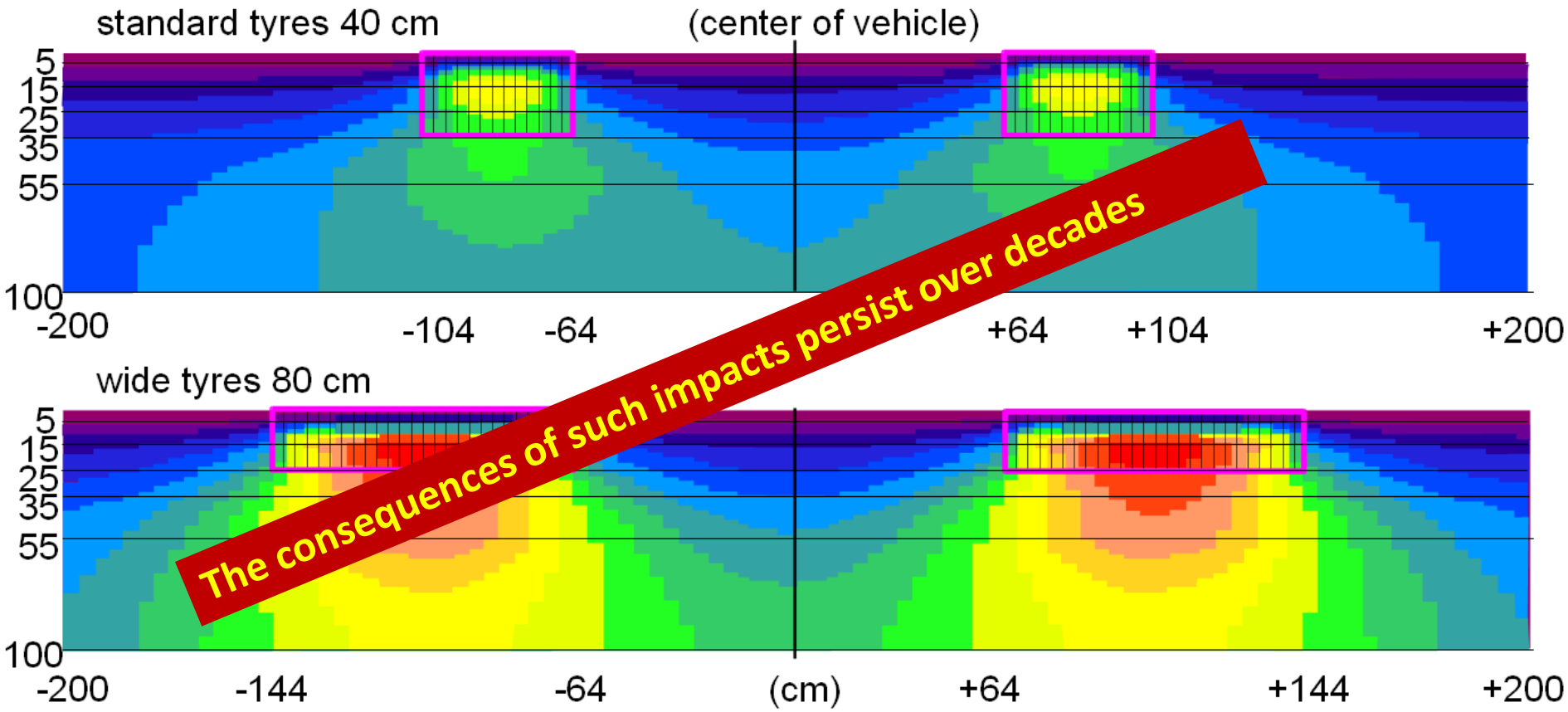
- reduced Infiltration
- prevented aeration
- water storage
- ponding

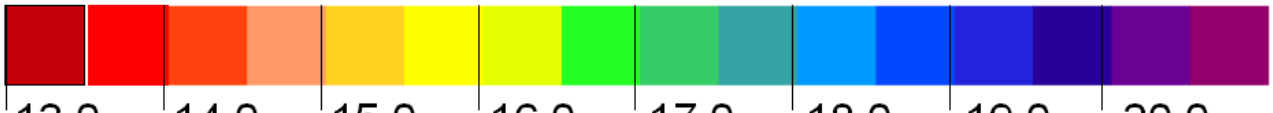
- root growth
- Water- , gas- and
- Nutrient uptake
- microbial activity

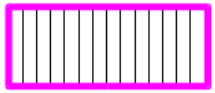
- **erosion/Land Sliding/ flooding**
- **nutrient loss**
- **water/ air pollution**
- **Gas emission**

•Yield Uncertainty Climate Change

Oxygen distribution under wheel tracks

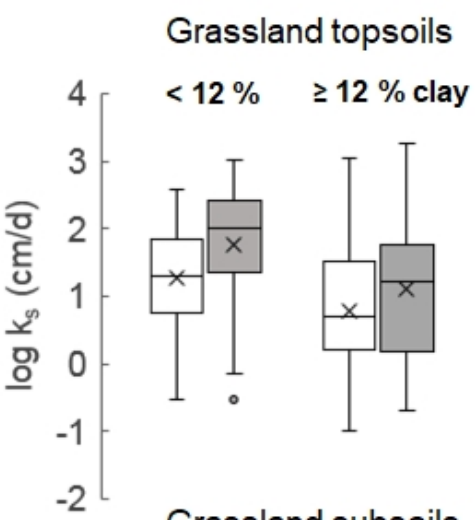


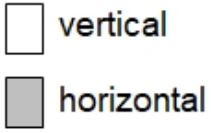


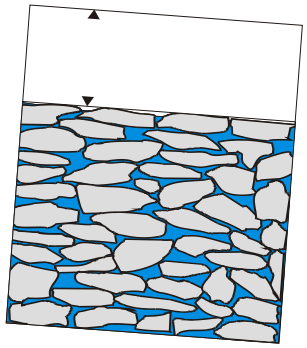


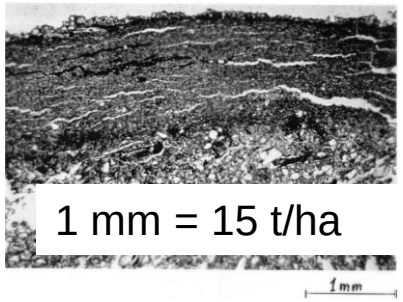
(Schack-Kirchner, Hildebrand, v.Wilpert 1993)

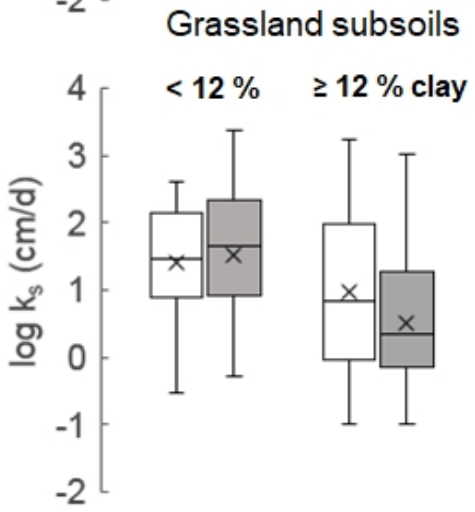
Effect of landuse on the tensorial function of the saturated hydraulic conductivity in Schleswig Holstein



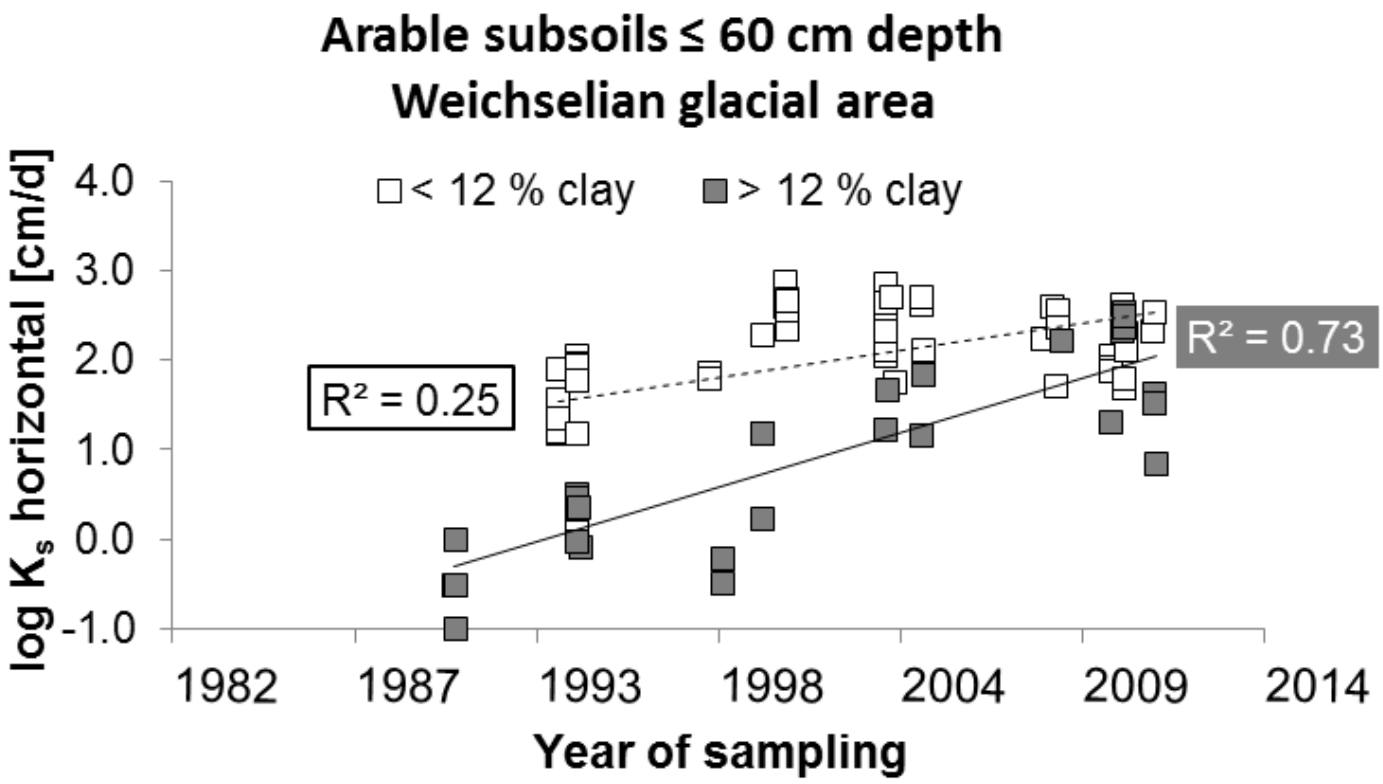






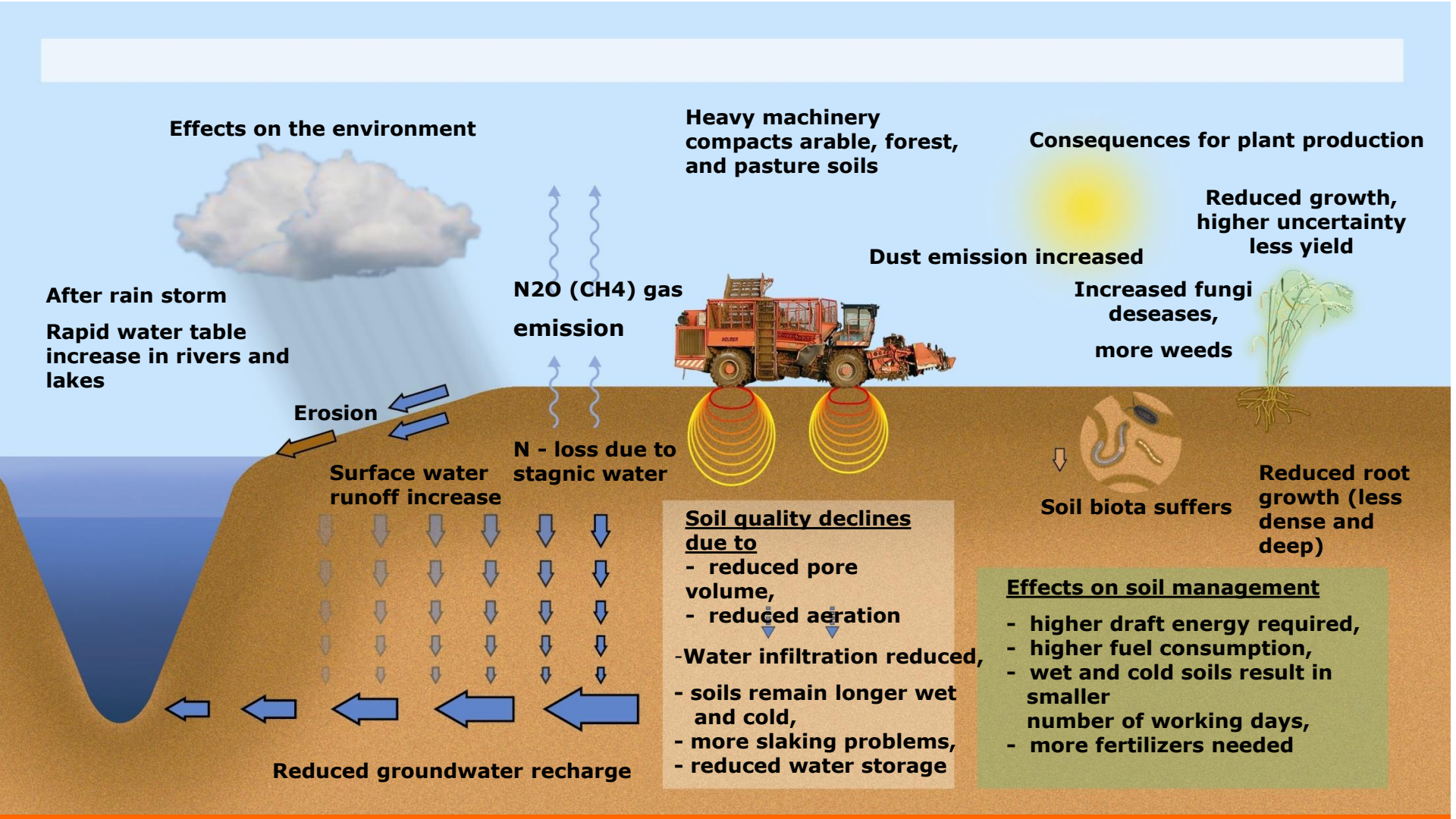


n=574 profiles



Horn et al. 2018 su

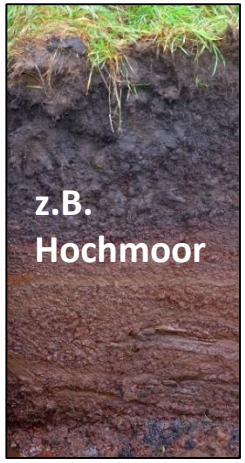
Soil degradation due to increasing soil deformation



Consequences of climate change: topsoil drought, reduced yield and carbon storage!

New anthropogenic impact: Electricity cable patterns in Germany from the North to the South (Bavaria) (7500 km)

Marschböden

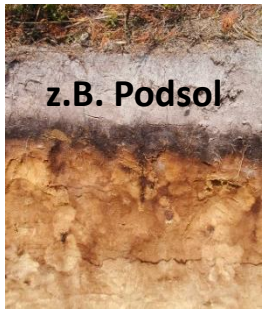


Hoch- und Niedermoorböden

Braune Lössböden

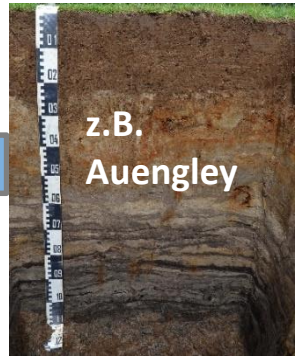
Böden aus Geschiebelehm und -mergel

Trockene Sandböden

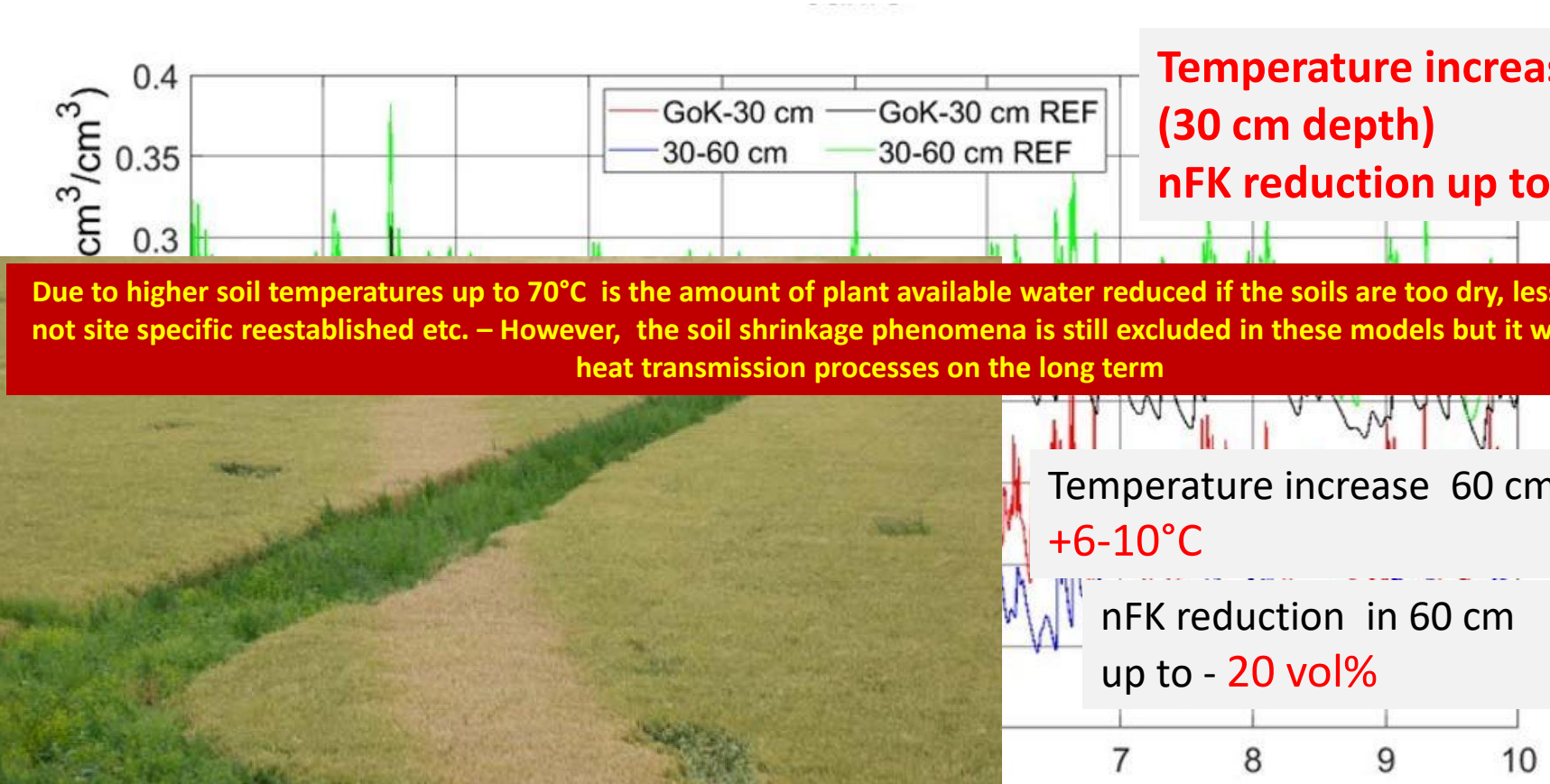


Schwarze Lössböden

Böden der Flussauen



Thermal interactions with soil water storage due to double cable installation (wheat growth)



Temperature increase +2°C (30 cm depth)
nFK reduction up to - 10%

Due to higher soil temperatures up to 70°C is the amount of plant available water reduced if the soils are too dry, less dense and not site specific reestablished etc. – However, the soil shrinkage phenomena is still excluded in these models but it will affect the heat transmission processes on the long term

Temperature increase 60 cm
+6-10°C

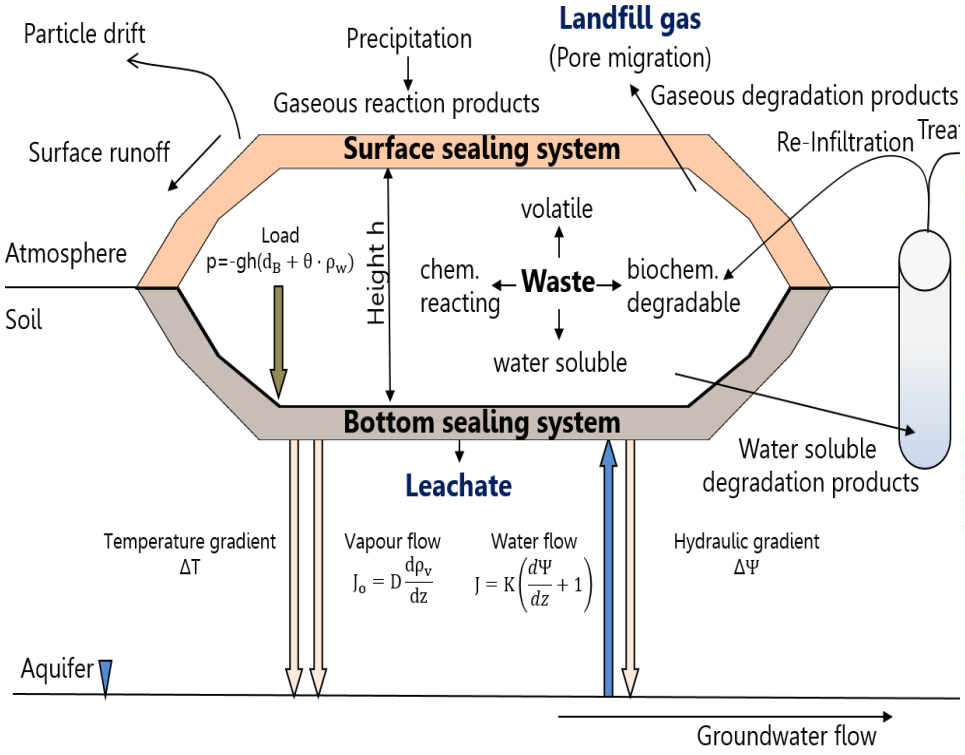
nFK reduction in 60 cm
up to - 20 vol%

Unpublished data

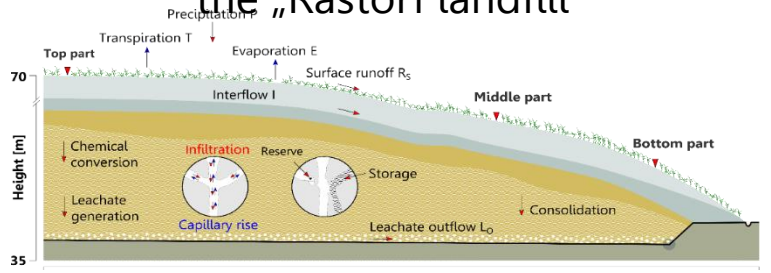
Loamy stagnic Cambisol

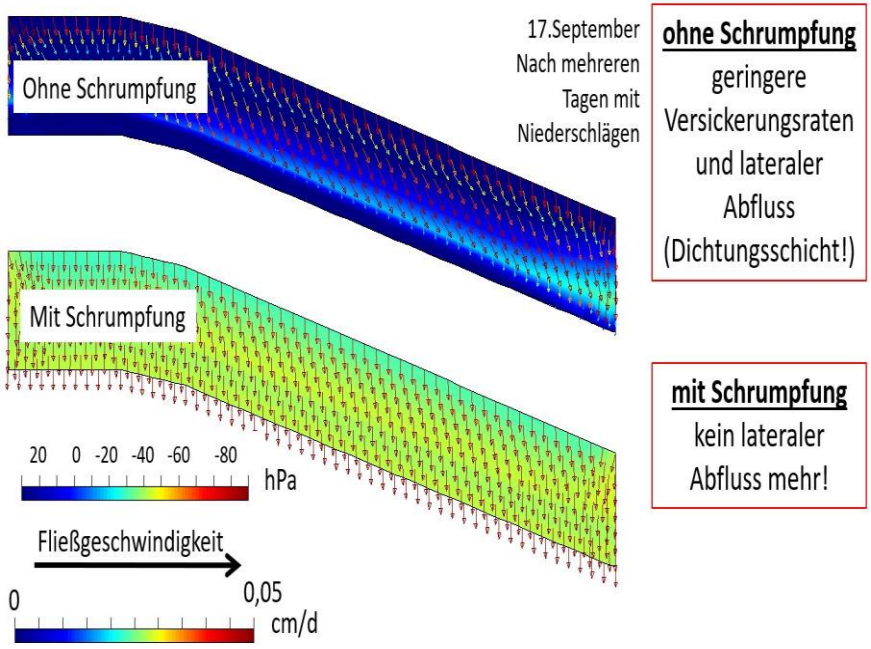
Environmental significance of landfills – how to guarantee long term impermeability but also possible mineralisation

- **Multibarrier concept**:
  - Minimizing the infiltration of precipitation → **Groundwater** protection
  - Prevention of landfill gas emissions → Protection of the **atmosphere**



Water balance of the „Rastorf landfill“





Which management strategies must be executed to counteract leakage due to climate change processes – topic of long-term safety

In short: we work also on anthropogenic influences like:

- physically: Sealing, land slides, erosion, compaction, desertification, improvement of water storage SWRT, waste deposit sealing systems, earth cable installation problems etc.

- chemically: (de-)salinization, pollution by organic and inorganic compounds, decline in organic matter, fertilizer application, liming etc.

- biologically: decline in biodiversity and biological activity.

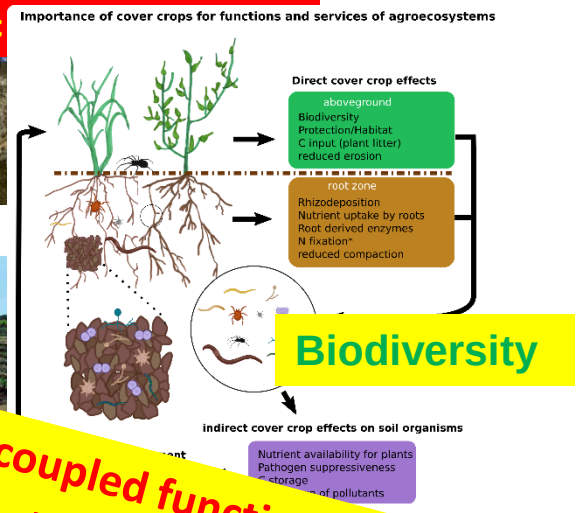
Discussion of Soil Protection & Sustainable Land Management

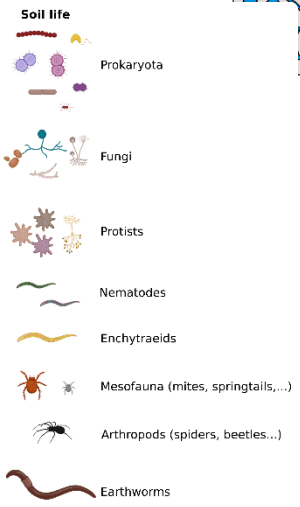
…….

….. always depends on our advanced knowledge, but also the link to the public, organisations and politicians

A few examples of urgently needed research topics: We must interest farmers, the public and politicians-

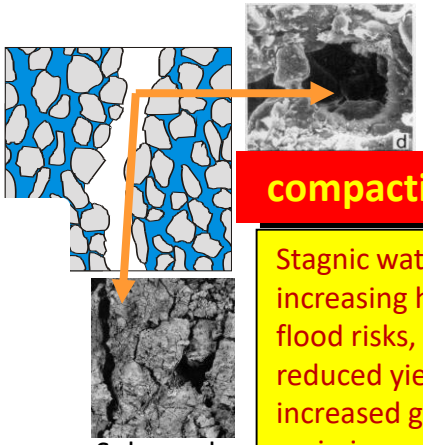
Environment and health topics like Arsenic





Biodiversity

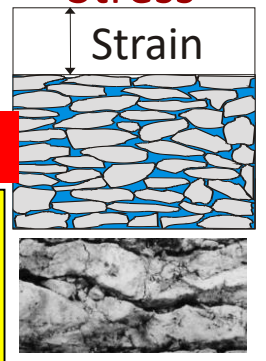
Soil erosion



compaction

Subangular blocky

Stagnic water, increasing high flood risks, reduced yield, increased gas emission



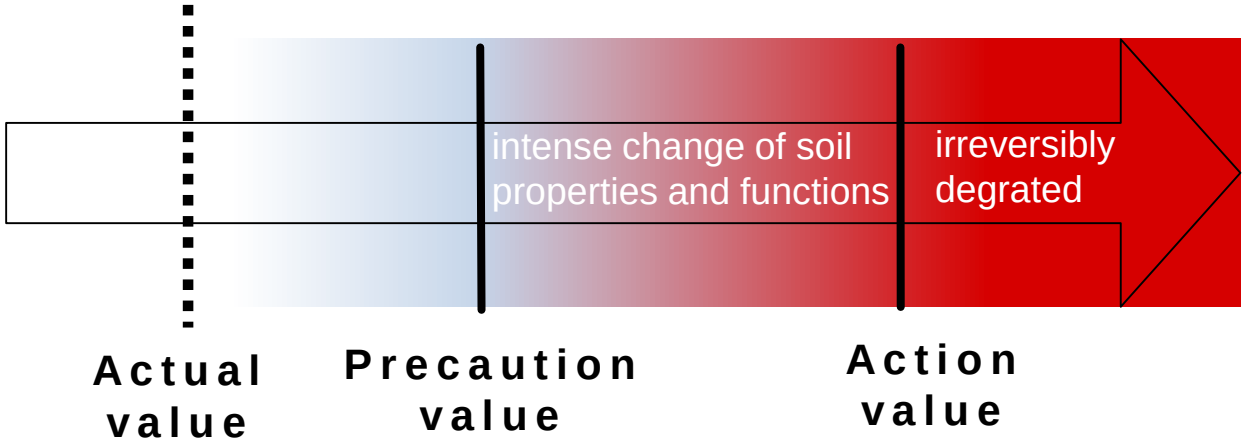
Platy structure

Soils, their coupled functions, limited resilience and related vulnerability are topics which request our complete energy and scientific activity worldwide

Land sliding

Climate Changes aspects

We know the relevant values for a sustainable landuse management -
we can apply our knowledge to maintain
<u>chemical, physical and biological soil properties</u>
an approach to formulate an European soil protection law



<u>Cadmium</u> (mg/kg dry matter)

- ***soil***
  (according to soil texture)

<u>Precaution value</u>:
clay: 1,5
loam/silt: 1
(at pH<6, precaution value like sand)
sand: 0,4

- exposure pathway
  soil - human

<u>Action value</u>:
- garden: 2
- Playground for children: 10
- housing area: 20
- park: 50
- industrial area: 60

Values for a sustainable landuse planning!
We can prepare recommendations to formulate laws
e.g. avoidance of soil deformation

Modified according to the German Soil Protection Law (1998)

In order to sustain soil properties and functions, a more site related land use and soil management strategy is needed!
We must intensify these approaches!!!

Actual value (Reference)	precaution value(PV)	Action value (AV)
Soil properties	**AC <8 Vol.%**	**AC <5 Vol.%, O2 availability**
	ks < 20 cm/d	**ks < 10 cm/d**
No problems e.g. Cambisol, Inceptisol, Spodosol (sandy material)	Labile soils : Loamy Alfisols E, (Bt), Cv ,	Sensitive soils: e.g. Kolluvisol, stagnic Luvisols, Gleysol , derived from glacial till or loam, Vertisols,

Actual values depend on: parent material texture, structure, bulk density, Corg. etc.

Soil is the Central Dogma, Soil Governance requires an intense and continuous support in the 21st Century

Picture taken from Jae Yang

Conclusions

IUSS is able to promote:

1. Continuous development of new insights in processes in and reactions of soils under various land use, climatic and anthropogenic inputs.

   - Development of site specific management strategies including the structure rigidity as boundary condition.

2. We know, that **landuse and soil protection are not conflicting each other, if the boundary conditions are considered – soil degradation must and can be prevented because it can not be reameliorated worldwide quickly!**

3. **IUSS has the potential to deliver the essential information for a more sustainable future land management**

Many thanks for your attention

Quelle: KIEL.SAILING CITY Foto: Peters