Colloque Européen des Académies d'Agriculture

"Science in agriculture: Historical perspectives and prospective insights"

„Providing knowledge toward an improved biota supported soil management, a timely challenge"

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AGRICULTURE ■ ALIMENTATION ■ ENVIRONNEMENT

TECHNISCHE UNIVERSITÄT MÜNCHEN

Soils are habitats; their biodiversity guarantees the soils

Soils: high density and diversity of organisms

☞ living ecosystems

Upper soil of a field/orchard:

up to 10 billion de bacteria/archaea and

env. 100 000 esp. (1 mio?) per gram soil

plus

fungi (hyphes)

micro-, meso, macrofauna

a handful of soil:

more organisms than humans in earth…

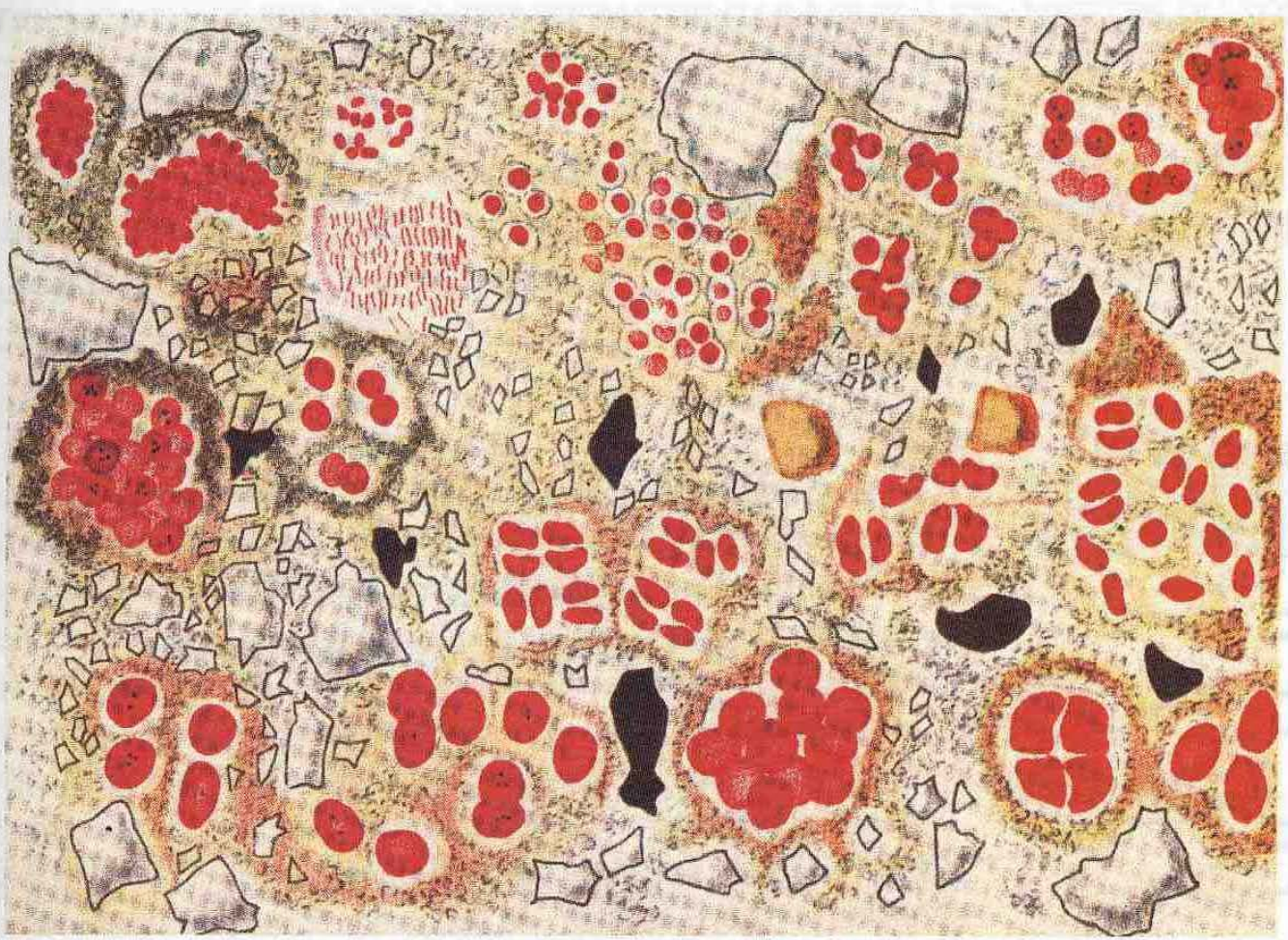
p.ex. soil: 1 – 10 Mrd microorganisms/ g !!! circa 100000 – 1000000 species/g

p.ex. humans: 100 Bil microorganisms/ individual!!! several 1000 species

intestine microbiome: 3,3 mio genes; 150x nbr.genes human biome

(only 200 bacterial spe.: identical for 90% of humans)

Genom: metagenome 1 g soil ~ 4000 x human microbiome genome



VII-1 Représentation schématisée de la microflore en place dans un sol agricole en jachère à Brie-Comte-Robert ; d'après Winogradsky (1949) qui la décrit de la manière suivante : « La *terre de Brie* est relativement riche en colloïde *(sic)*, tant incolore que coloré en jaune brunâtre, et qui recouvre tout le fond des préparations par ses flocons. Quantité modérée de corpuscules noirs ; quelques corpuscules jaunes brillants. » Avec l'autorisation des Editions Masson et Cie, Paris (§ 2.5.2).

Soil - Soils

What are soils ?

Products of an evolution, during
thousands of years

Each one, a site specific product :
geol. substrate, topography, climate/meteo cond.;
⇨⇨ **„Soils“**

Organization of the complex construct
(hierarchical system of porous aggregates with reactive surfaces),
is highly stable,

Composition: mineral & organic substances ,
highly **complex live** (communities…),
water/ solution, air (soil atmosphere)

- Pore volume: up to 50 vol.% of the soil

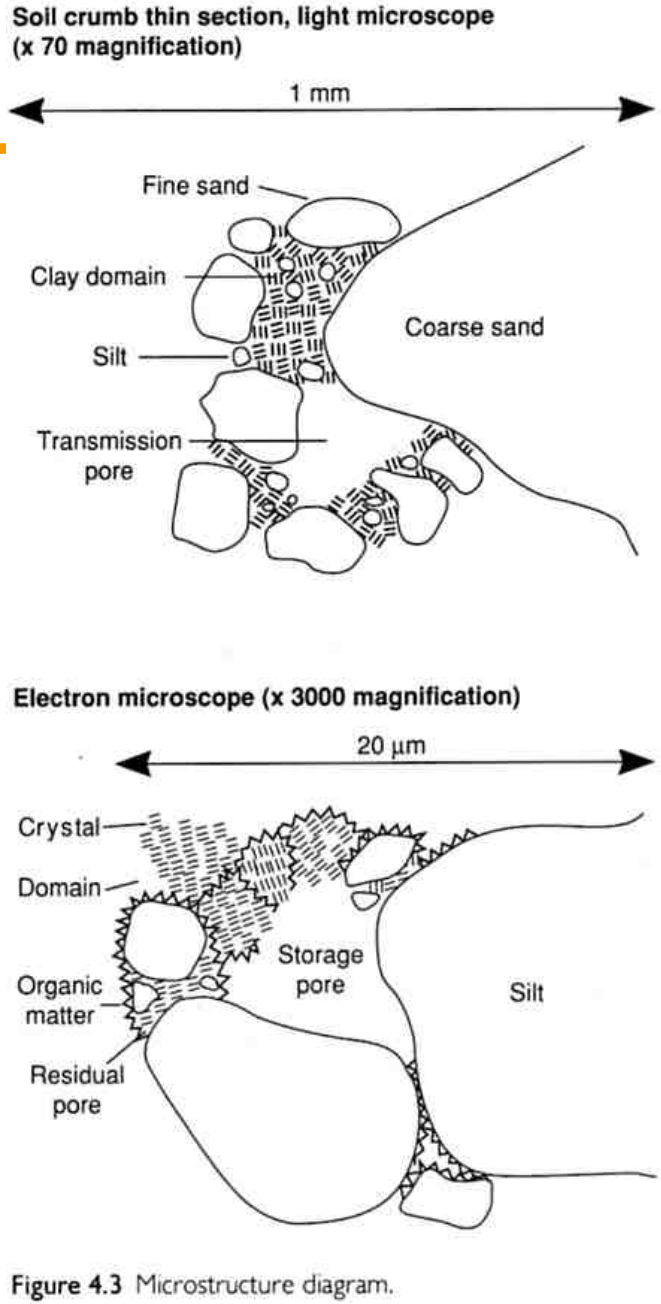


Figure 4.3 Microstructure diagram.

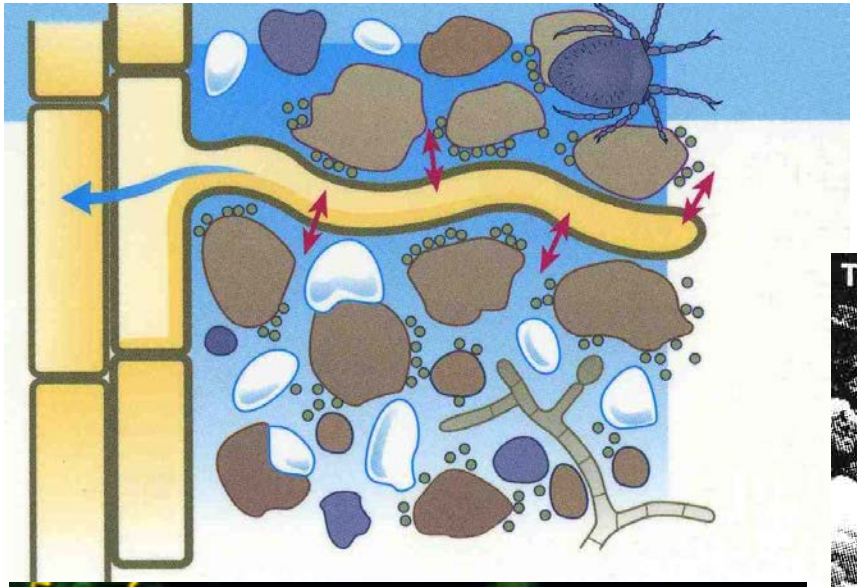
Life conditions for soil organisms

Free spaces = pores in soils (99% <1mm, not habitats):
filled with air + water (solution + solutes)
with always changes in air-water relationship
with variable substrates (vegetation state etc.)

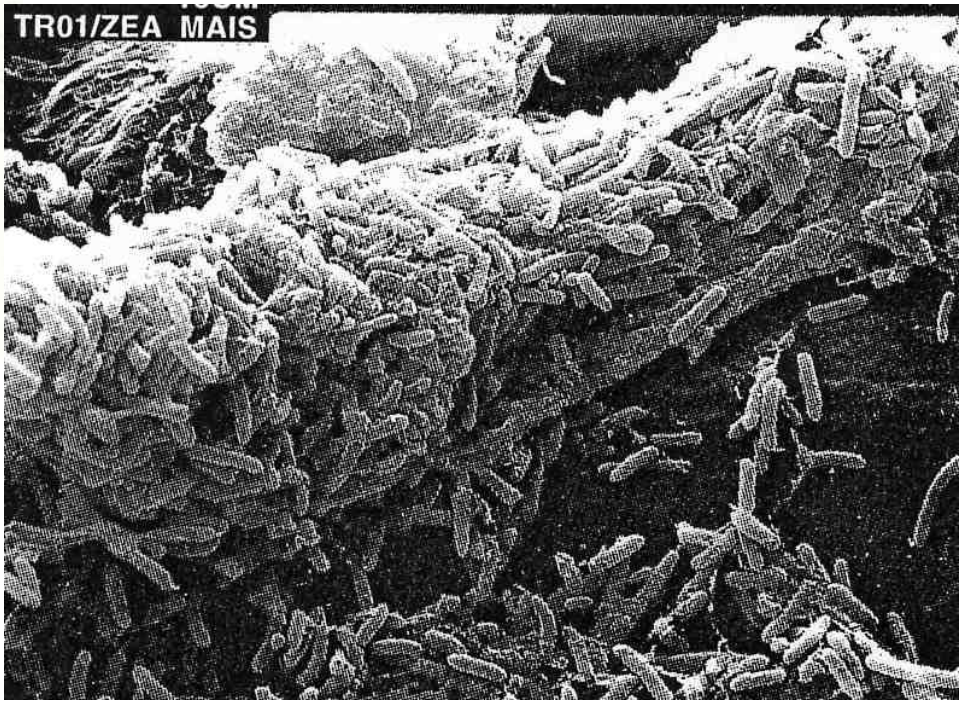
Inside pores:
microorganisms in water(film) on surfaces
on surfaces of pores
on organic particles (substrates…)
on roots (substrates…)
microorganisms free in water in case of filled pores

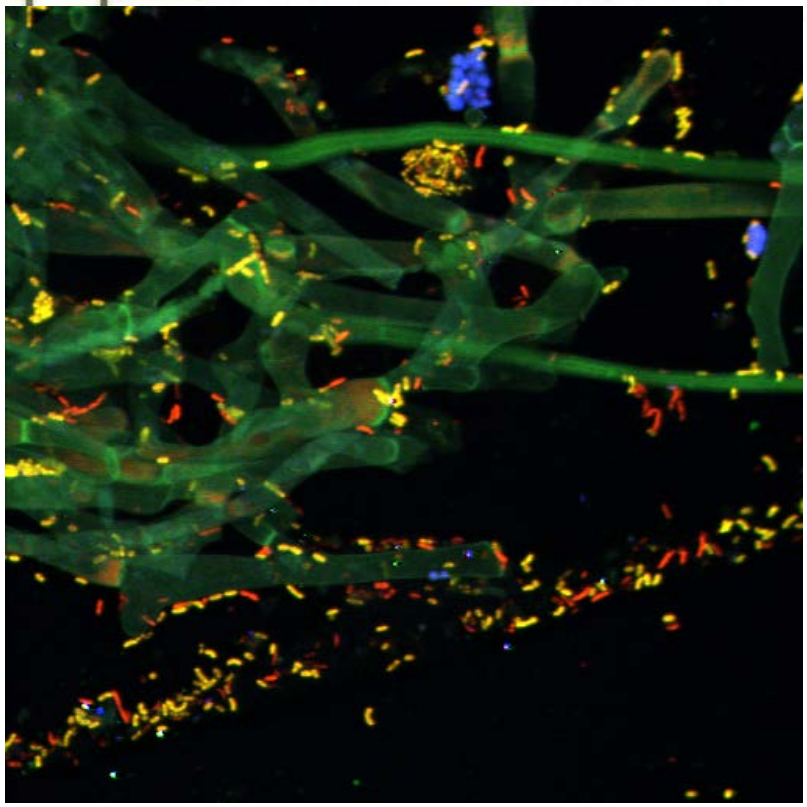
Faunal intestine : more constant habitat conditions

· extreme heterogeneities of ecological conditions
· strong regulation of "life", selection of actives according timely needs, dormancies ; lysis of populations ⇨ free energy for actives



The rhizosphere, hot spot for microbial colonisation and activities





Diversity of bacteria associated to hypha's of telluric fungi

confocal laser scanning microscopy, fluorescence after in situ hybridisation with phylogenetic markers, each with a fluorescent dye.
(from: C. Kellermann, Hemholtz Zentrum München)

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Biological, microbial activities: countless !

Formation and conservation of soils :

transformation of plant residues into humics;
formation of the soil « system »

Numerous transformations of materials, p.ex.

transformations and mobilization of elements (organic + mineral)
◊ availability of nutrients – growth of plants

interactions with roots: symbiosis, control of phyto-pathogene fungi and bacteria (bio-control,…)

global cycles (return of N_2 to the atm.)
degradation de foreign substances (from deposition, pesticides, antibiotics from husbandry)

…

No soils, no soil functions without biology, without micro'orgs

Discovering ecological conditions of soil microorganismes

oekos = house, habitation; conditions = environments

- understand them , esp. for highly heterogonous soils ?

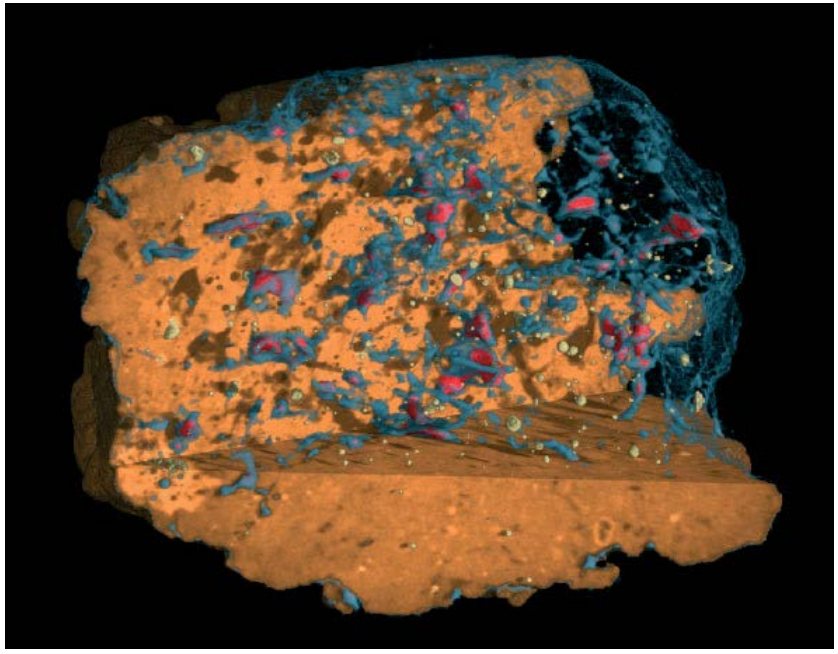
some examples
with actual analytical possibilities at all scales :

micro site

field

Microcompartments, sites for microbial life

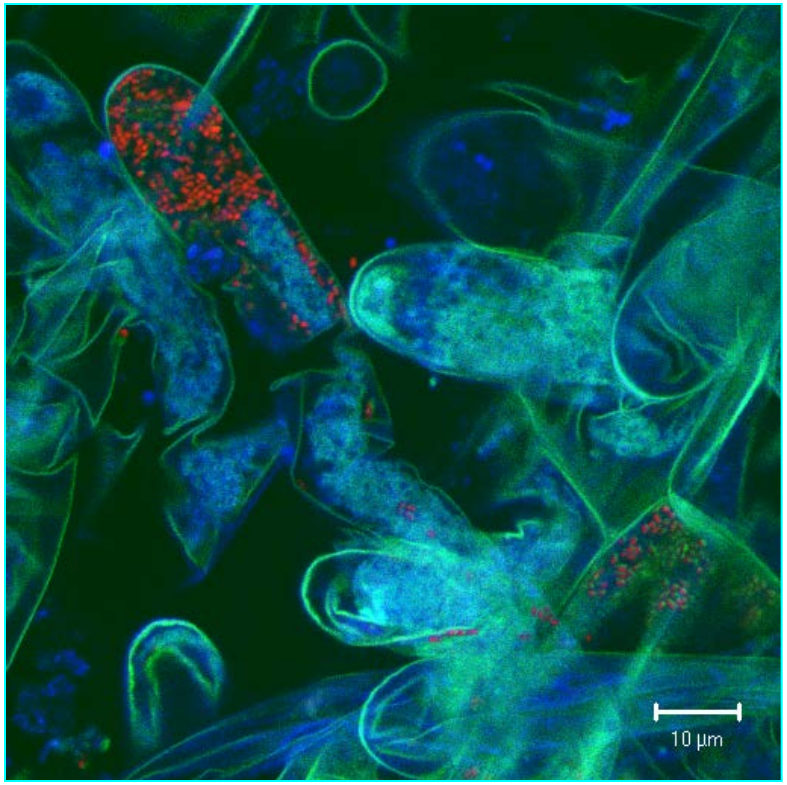
Actual analytics: showing pores & structure inside soil aggregate showing microbial signaling



Aggregate inside

mini computer tomographie
diameter: 2 cm

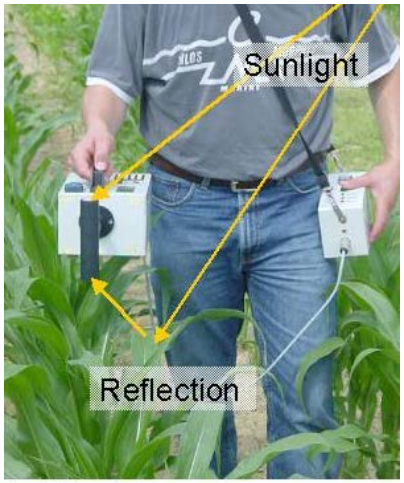
Helmholtz Zentrum UFZ, Halle, H.J. Vogel



Dialogue bacteria - roots

Red: bacteria on corn roots, synthetizing
homo serine lactone
(+ marker fluorescent red)
Helmholtz Muenchen, T.Hartmann

Plant and soil analysis, *on line*

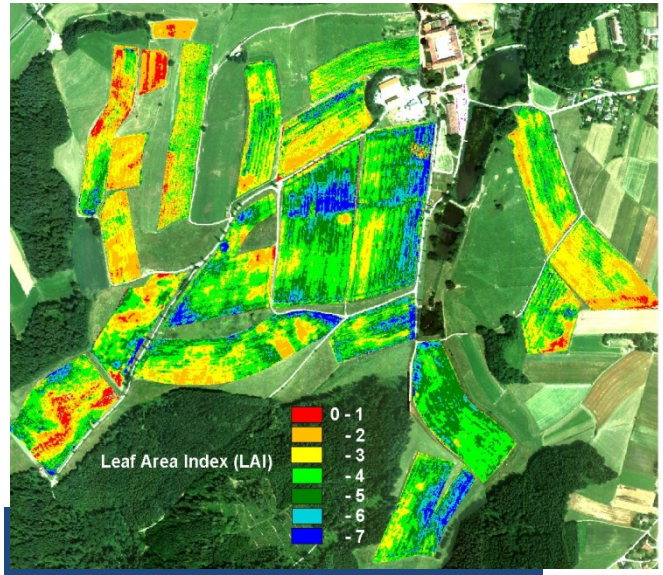


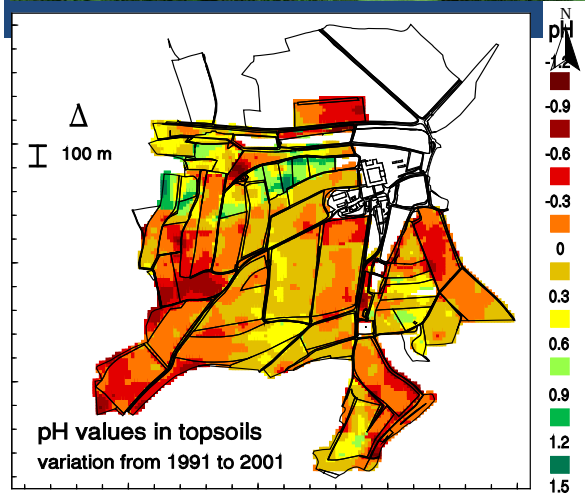
Wireless Soil Moisture Sensors

Remote Sensing

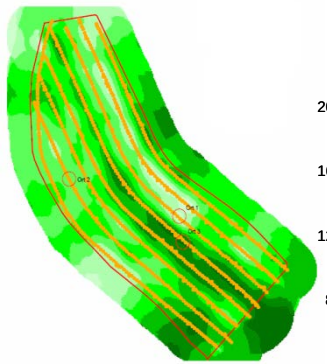
big data ……,
serving soil microbiology?

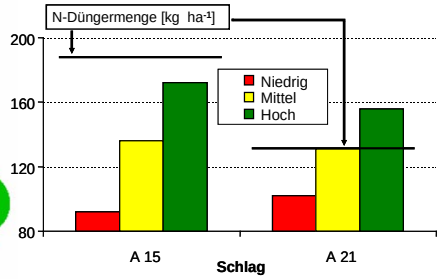
Remote sensing operation :
Estimated LAI airborn, 300 m altitude
Ferme Scheyern





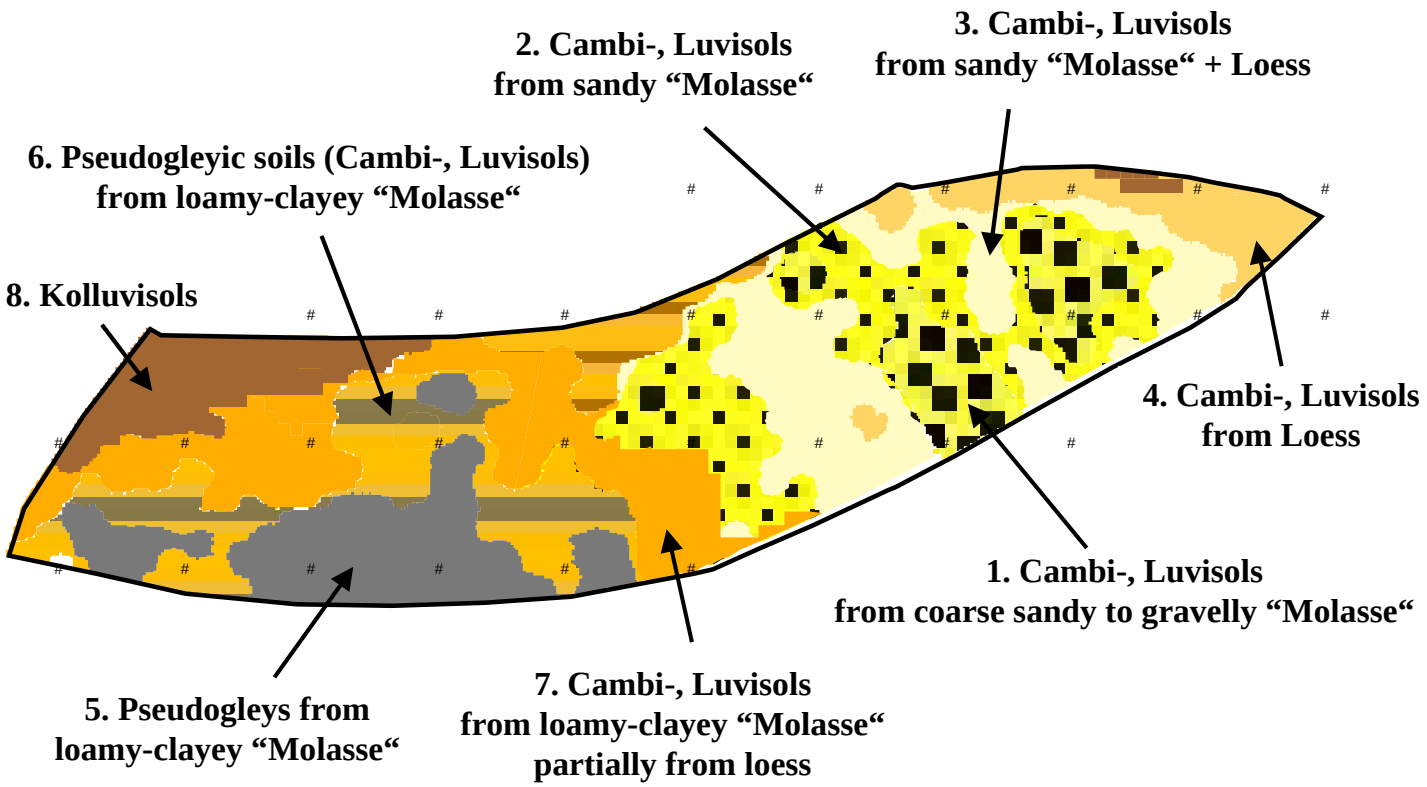
Non invasive soil analysis:
EM 38
Farm Scheyern





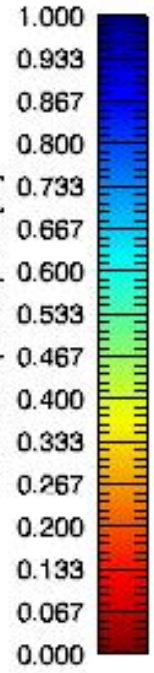
Soil maps, ...

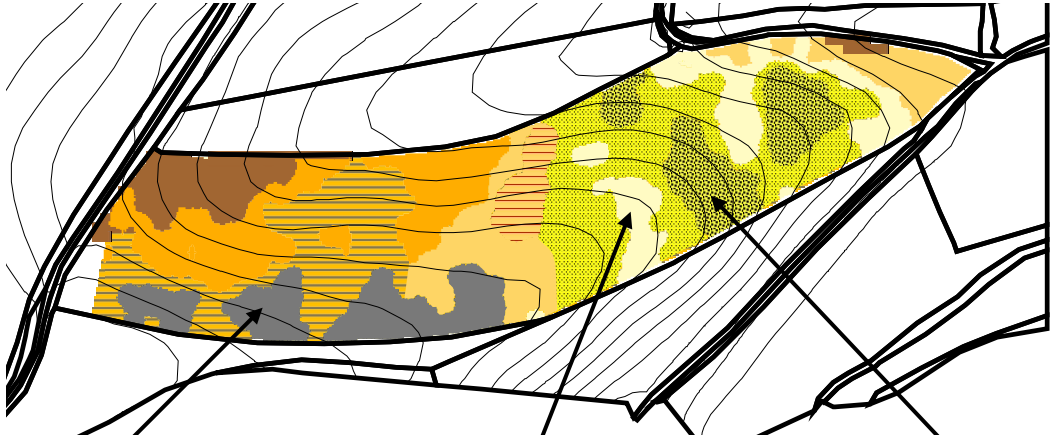
Field, Farm Scheyern/Germany

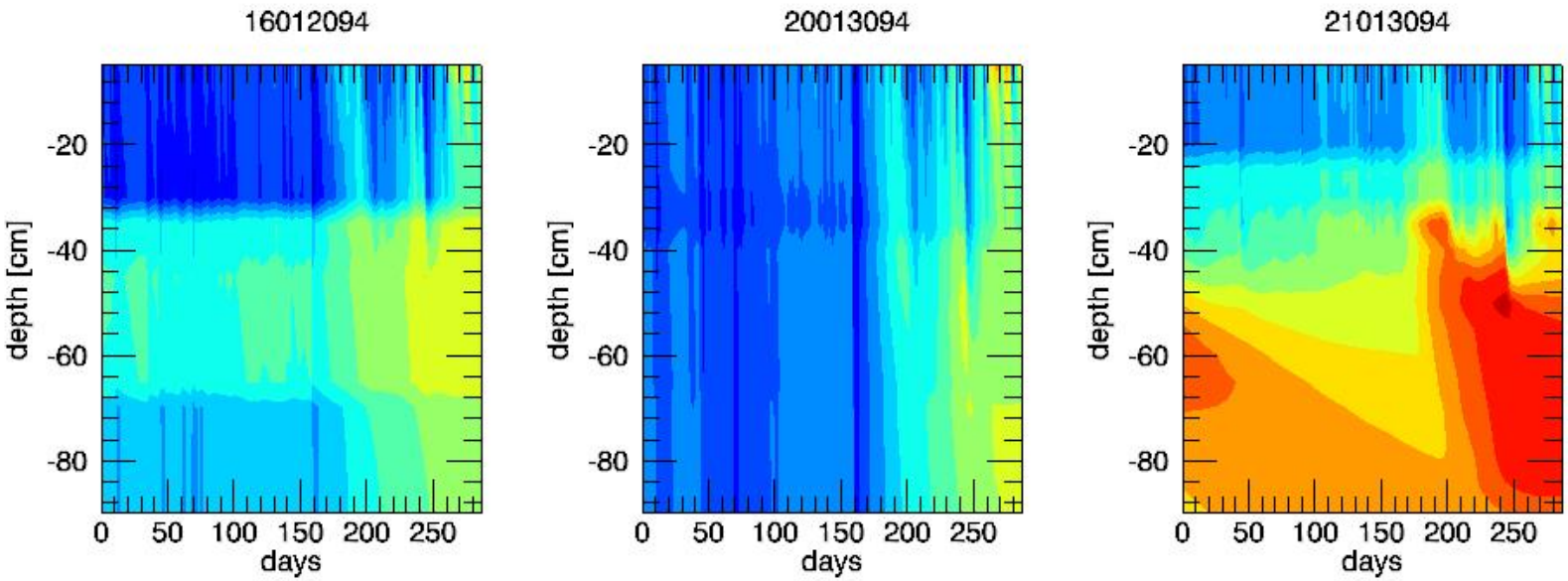


Pedodiversity and functional diversity

Water Filled Pore Space

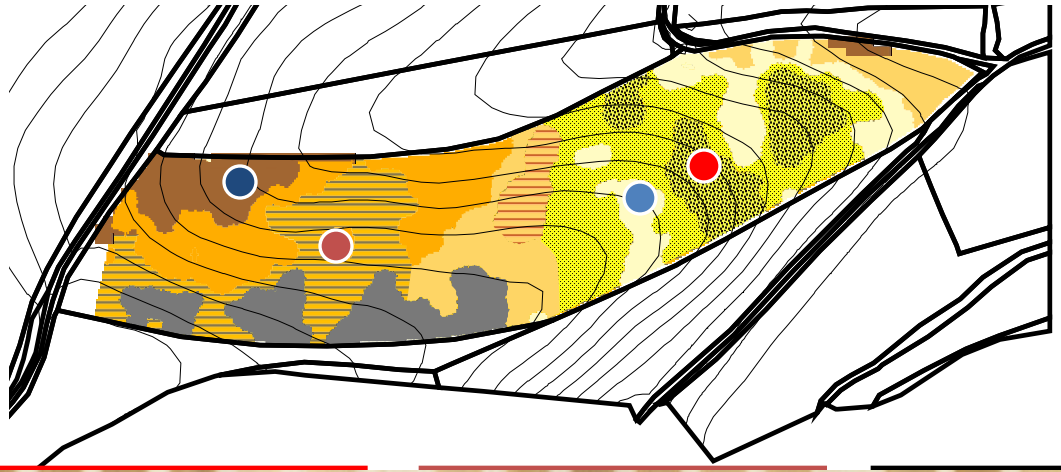






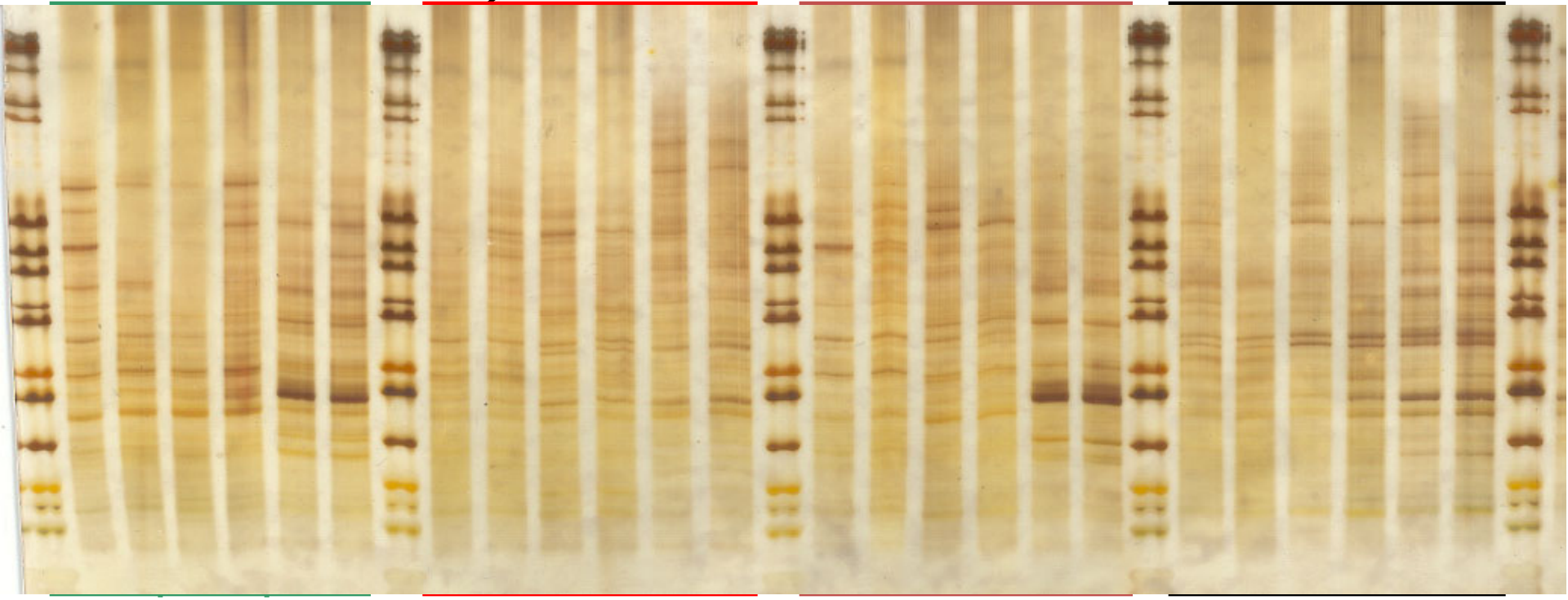
Pedodiversity and functional diversity

DNA Fingerprinting microbial DNA



Depth [cm]

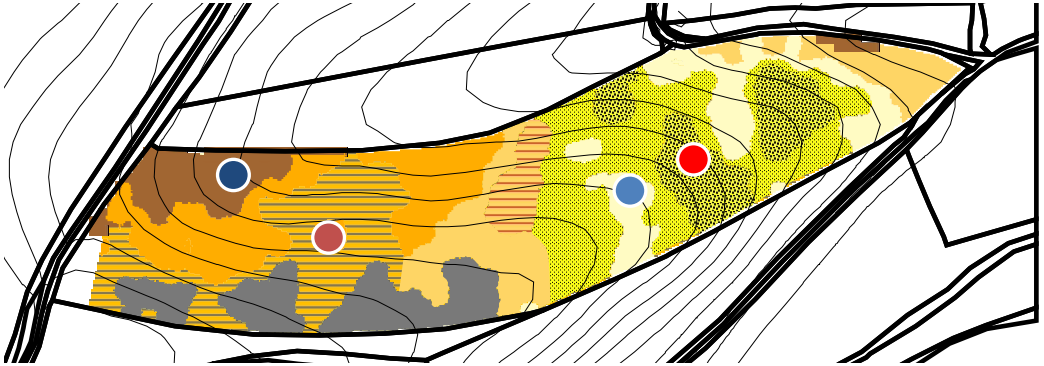
0 -10 - 28 - 40

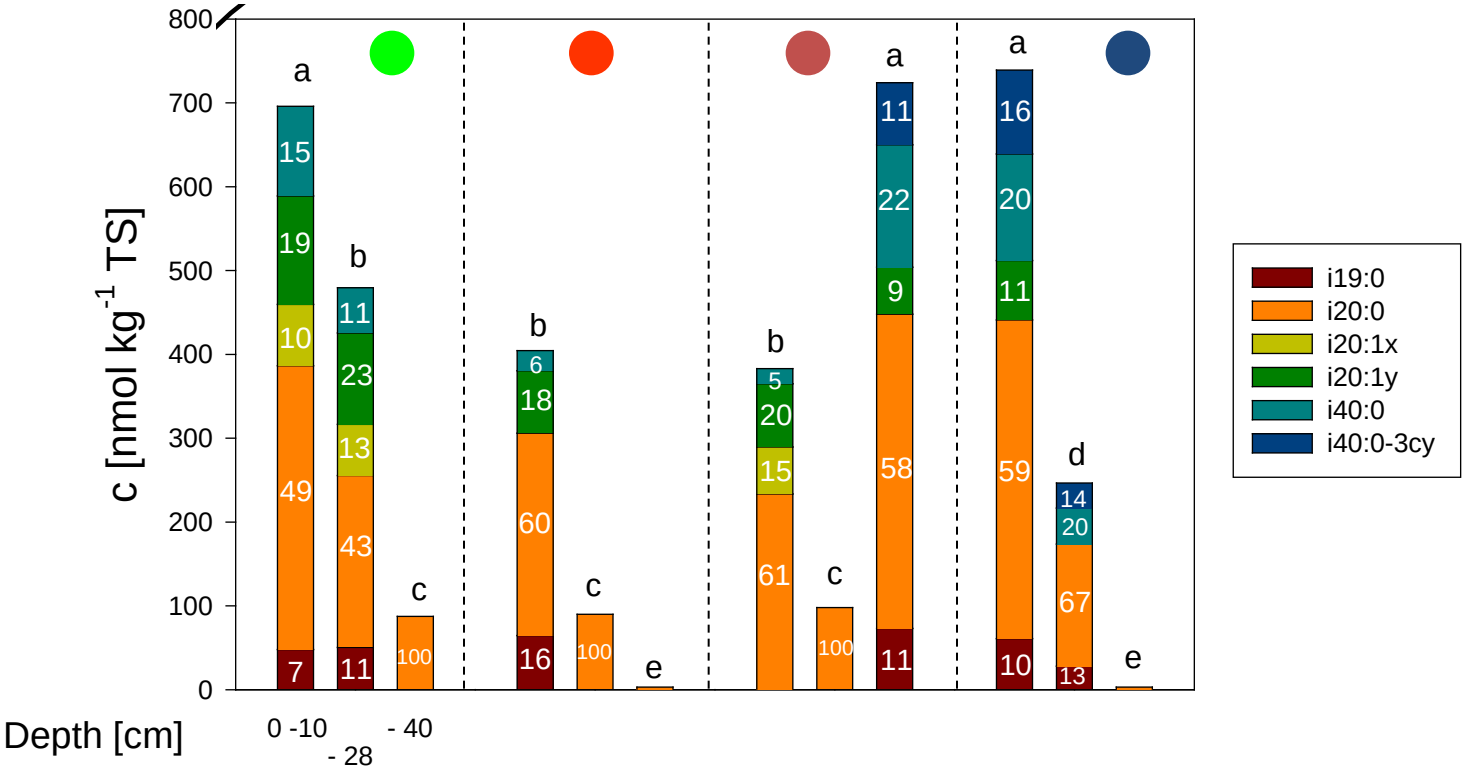


Pedodiversity and functional diversity

Archaeal Lipids (PLEL)

- **methanogens**





Why this rich biota? Gratuitous luxuri?

Soil development is biota based, with (photosynthetic) residues allowing
- energy inputs (per primair photosynthesis) and
- the transformation of organics in soil organic matter,
  indispensable for soil structure formation/conservation and functions.

Time and space *heterogeneities need a high organismic diversity*
with all genetic potentials coding for all needed functions,
under all *constellations of conditions*.

Soils steer these organismic populations and communities,
optimizing the utilization of available energetic resources.

Soils are living entities, holobiotic systems.

Wh

Need: better soil use, soil preservation

Soils are endangered :

politicaly - societal and economical pressure
urbanization
climate change

Soils need a management

that preserve/conserve soils
reduce negative impacts
more based on the soil resources

Soils and human nutrition

World soils:

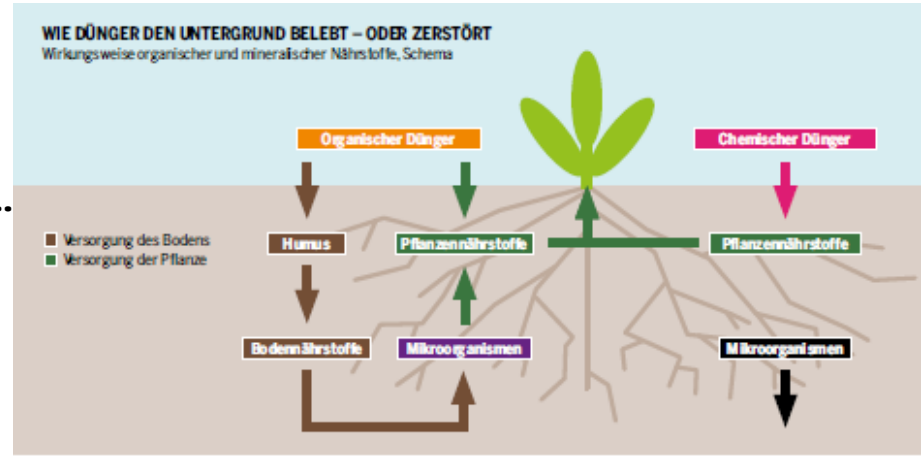
1/3 of soils: non usable,
arid, frozen, snow + ice covered

Soils with vegetation:

31% forests
36% usable for plant growth „alimentation"
24% meadows, grassland (partialy: food over animal feeding)
12% arable (= human nutrition, food)
(• 1/4: for global market ,
• 3/4 for farmer needs)

Need of management with

- soil conservation/rehabilitation … ..
- yields – sufficient
  - high quality
- minimum of environm. risks



Der kürzeste Weg ist nicht immer der beste. Mikroorganismen sterben ab, wenn der Dünger nur die Pflanze versorgt

Dangers by soil compaction

Examples of life space destruction in soils

- Soil compaction and loss of pore spaces
  p.ex. heavy equipment,
  tilling at inappropriate time (high soil moisture)

-> the pores are the life spaces ;
no biology without adequate porous space,
without soil aeration

-> pores allows water retention, water ☞the real life space

Soil compaction

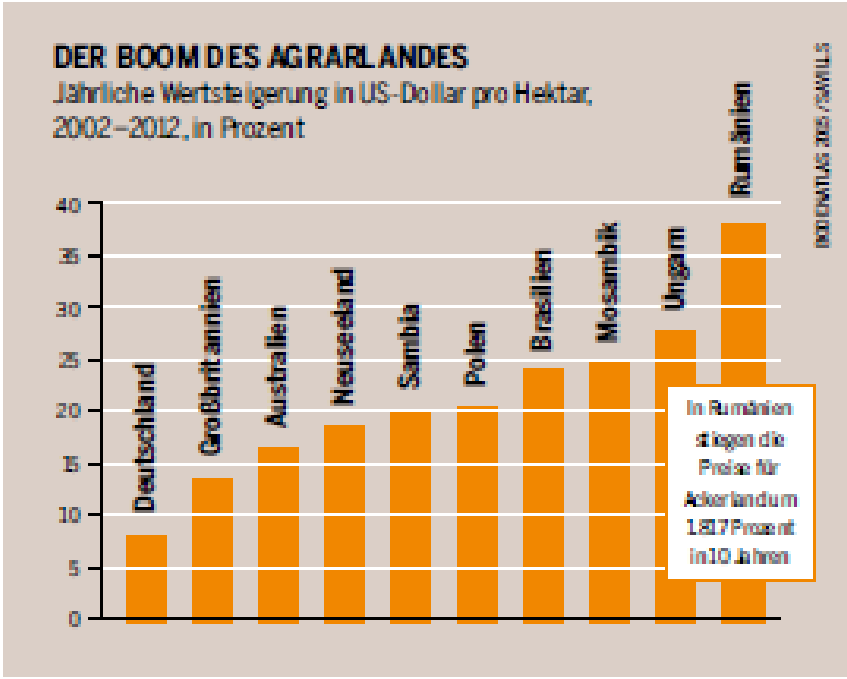
Compaction, harvesting systems

A more global view: humans and soils

Soil grabbing in poor countries

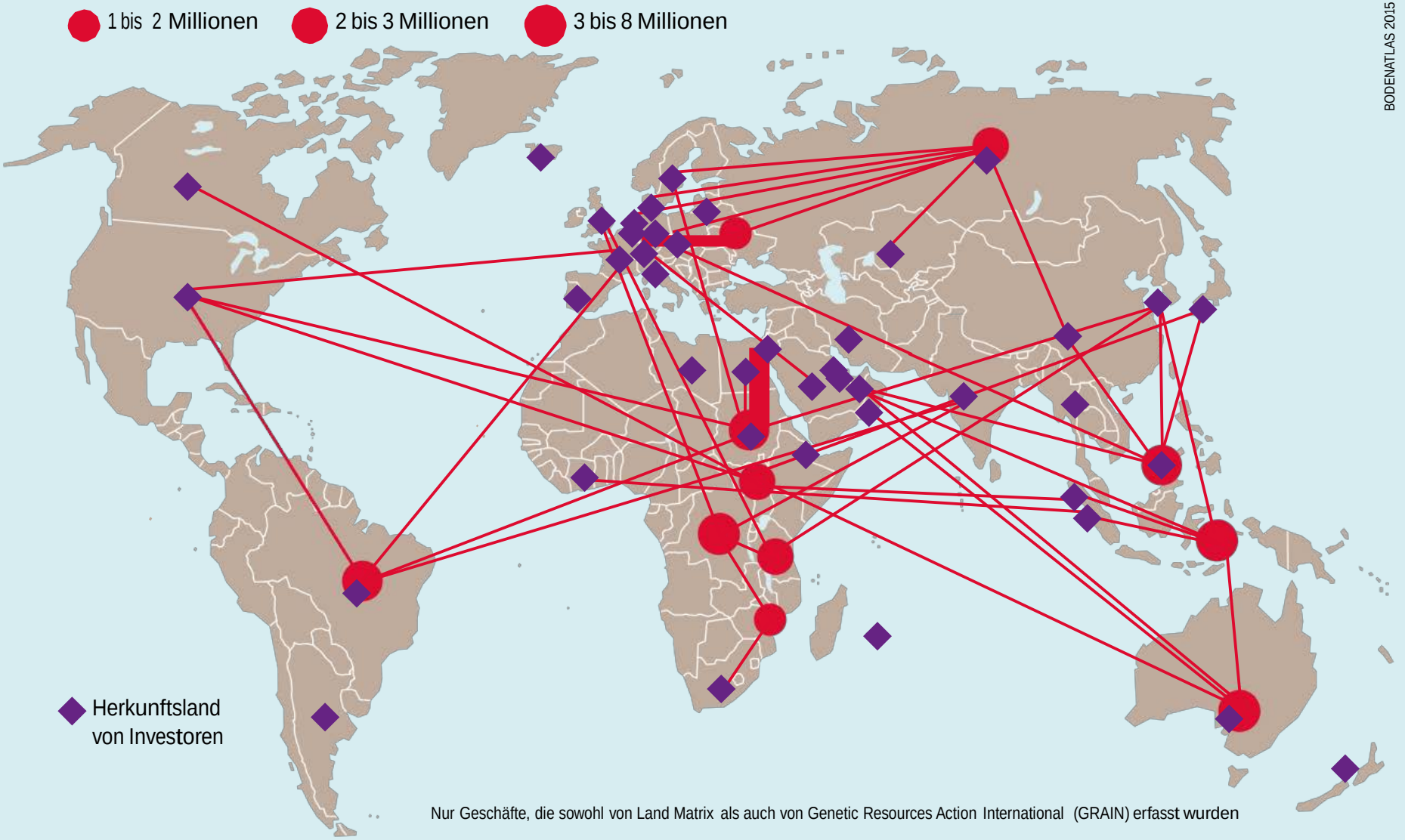
- Germany/France/Europe in Africa and South Americ
- China in Africa and Eastern Europe
- India, Korea in Africa
- Saudi Arabia in Africa
- •Stock exchanges /financials at world level

► actually > 80 Millions ha



WER KAUFT WO?

Landübernahmen in den 24 wichtigsten Zielländern, mit Herkunftsländern der Investoren, 2012, in Hektar



BODENATLAS 2015 / RULLI U.A.

Ein Netz der Gier: Riesige Flächen wechseln den Besitzer. Die meisten „Grabber" kommen aus den Industrie- und Ölländern

Danger by climate change: a example considering forest soils

•A) Tropospheric ozone and plant growth

• 2017, January 11th, presentation at AAF

"L'ozone anthropogénique, un risque global pour le climat et l'alimentation de l'humanité »

•**Background:** "Ozone and its Precursors (VOCs)"; loss of agricultural yields; wheat crop losses of up to 15 per cent; hinder the growth of forest trees and have a negative impact on the carbon storage capacity of forests – and on soil functioning by less organic inputs.

•B) Air humidity, plant growth and soil

•**An example, based on experimental field approach**

•**Background:** "At northern latitudes a rise in atmospheric humidity and precipitation is predicted as a consequence of global climate change »

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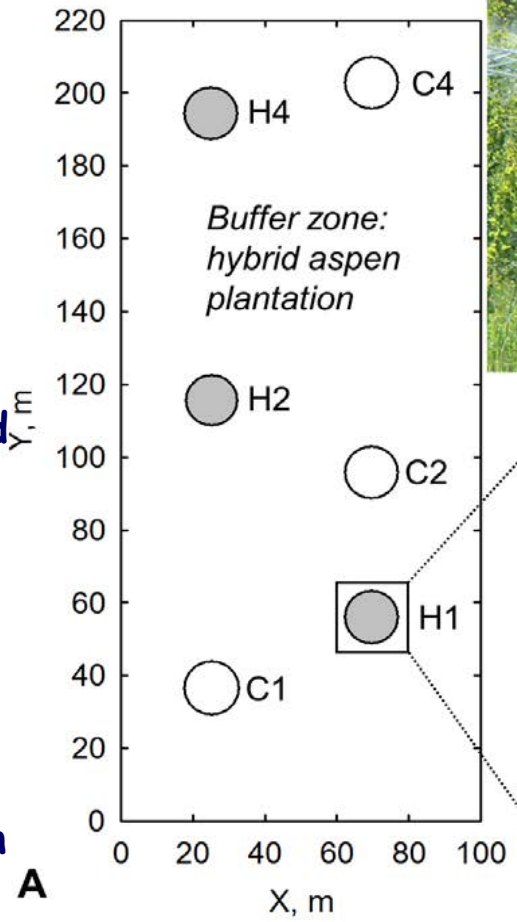
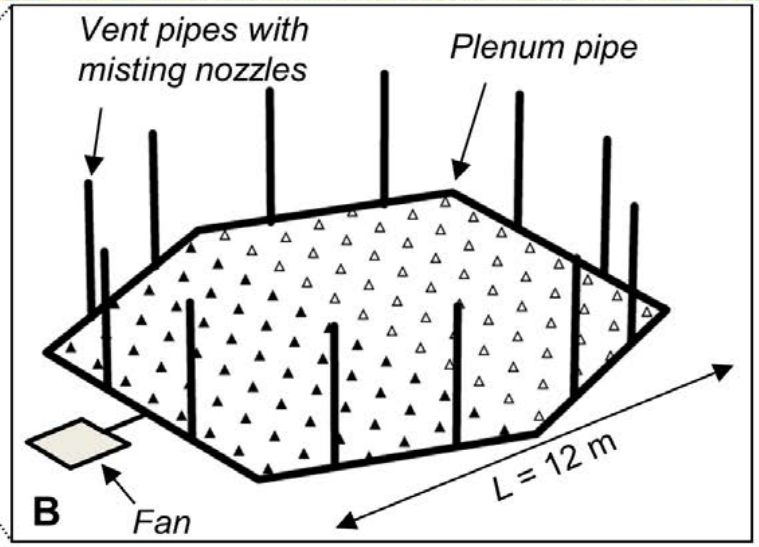
Experimental divice, in Estonia

FAHM experimental area:
a) locations (X: distance from the west edge, Y: distance from the south edge) of control (empty circles) and humidification plots (filled circles),
b) general layout of a humidification plot comprising trees - hybrid aspens (filled triangles) and silver birches (empty triangles), L indicates the distance between opposite vent pipe pairs
c) photo of the humidification plot taken in July 2009.
doi:10.1371/journal.pone.0042648.g002





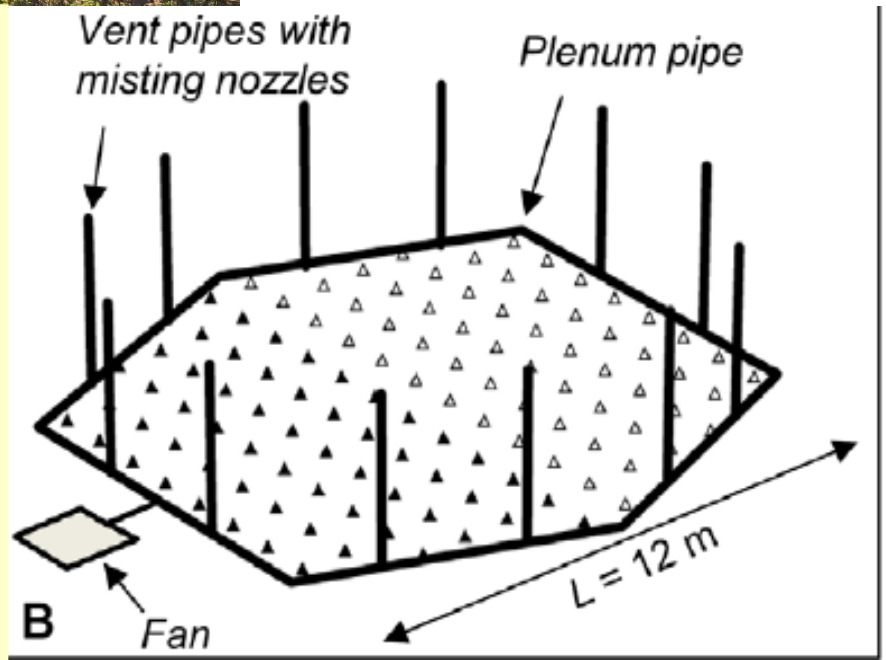
Tullus et al., PLoS One vol 7, 2012

http://www.lote.ut.ee/FAHM/in-english

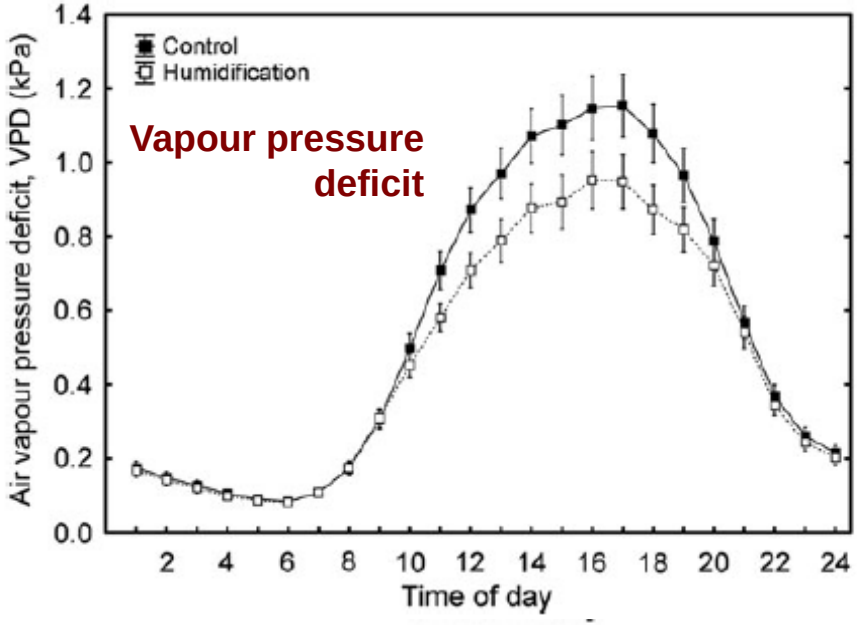
FAHM experimental area:

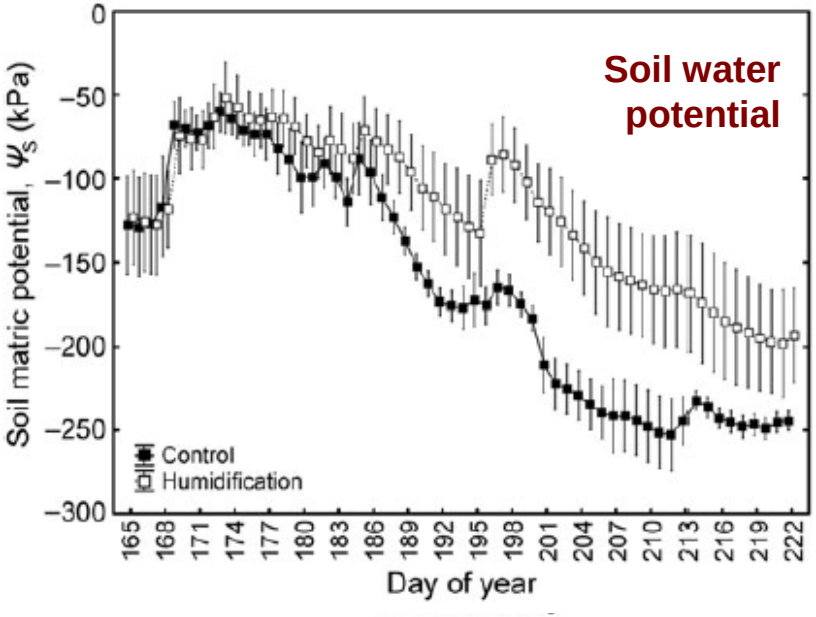
Photos: R. Matyssek

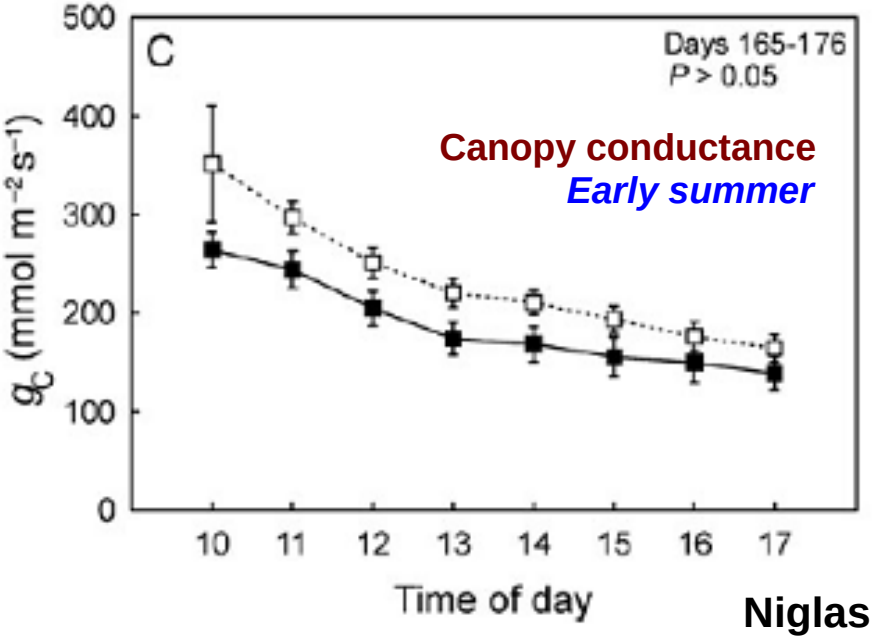
Tullus et al. (2012)

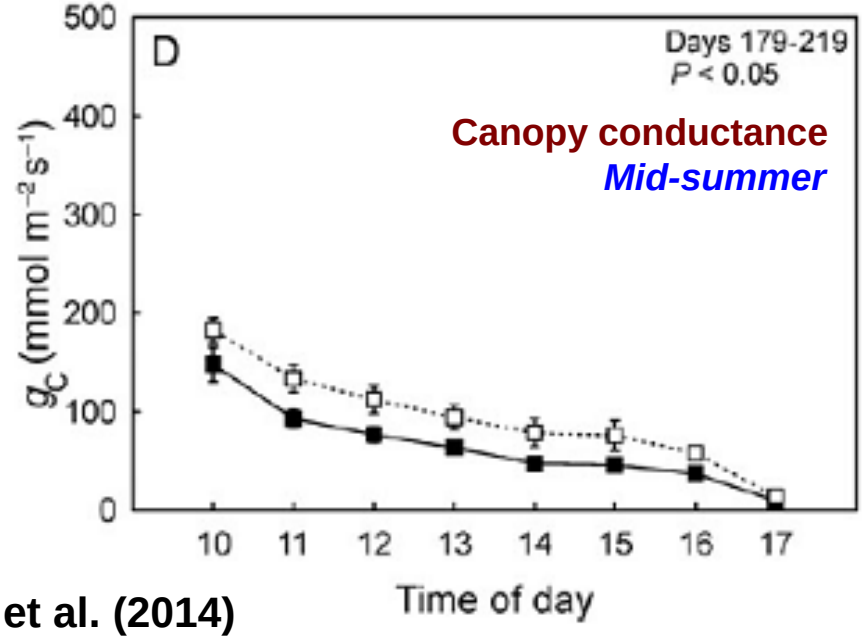


Effects on







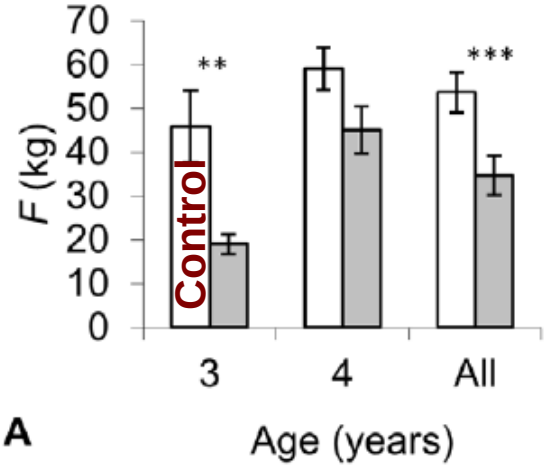


Niglas et al. (2014)

Effects on

Populus tremula x tremuloides

Xylem sap flow



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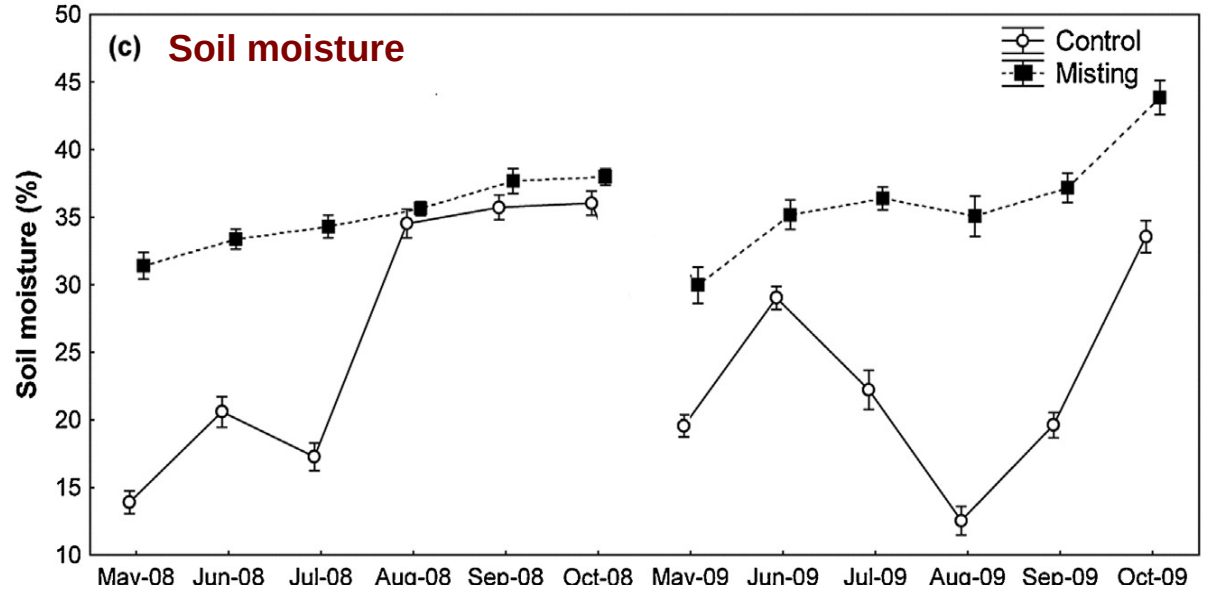
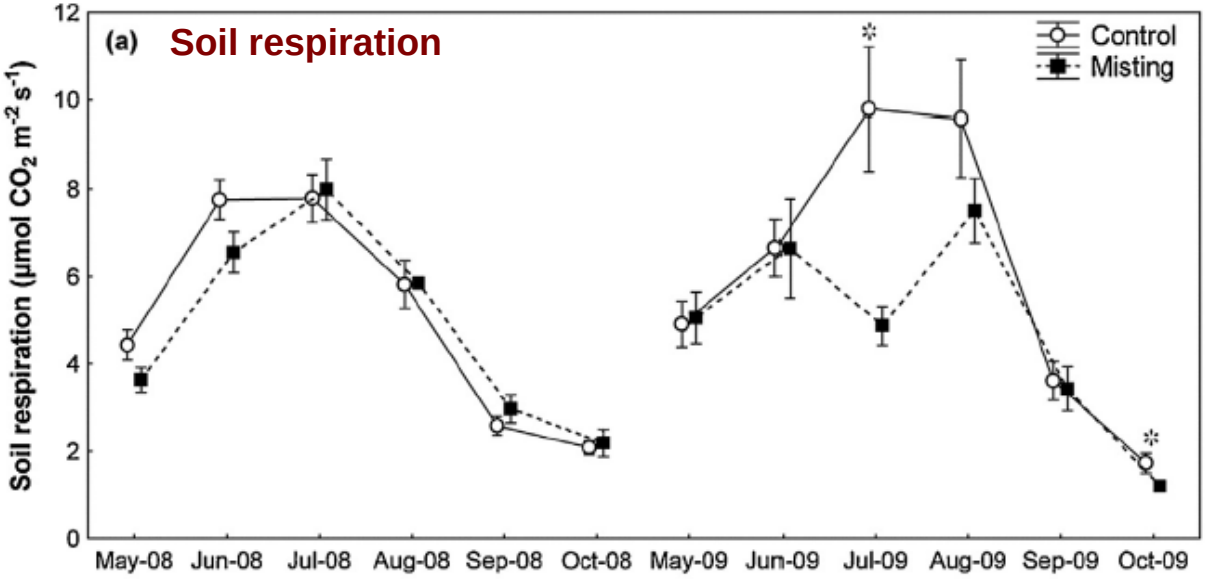
Tullus et al. (2012)





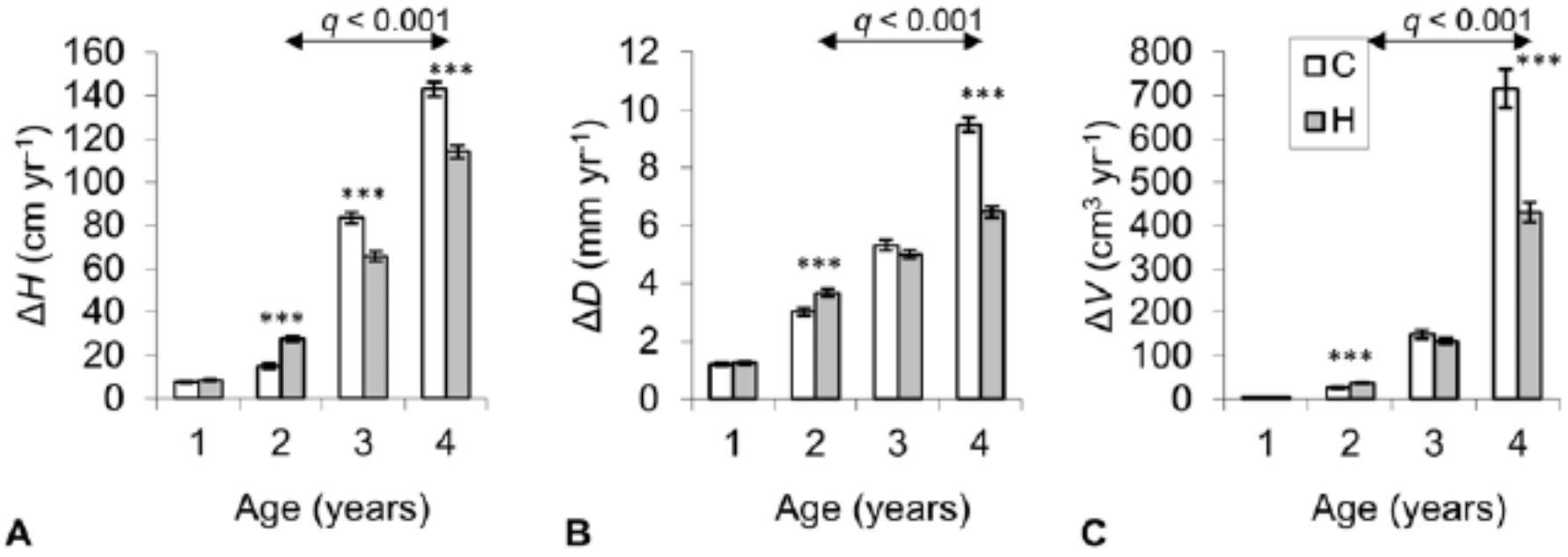
Kukumägi et al. (2014)

Effects on stem increments in

Height

Diameter

Volume



Tullus et al. (2012)

Conclusion

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Soils and ecosystems, the basis of our life by delivering food, fibers, raw materials and essential functions

◊ are endangered by non adequate use and societal pressures

◊ are endangered in several regions in course of climate change, also in the function of delivering materials, and esp. in their own existence

◊ need an European scientific initiative of protection and of appropriate research fields, so by initiative/support of EUAA

A private European citizen initiative

People4Soil:
sign the citizens' initiative to save the soils of Europe!

Soil is one of the most strategic resources of Europe, as it ensures food security, biodiversity conservation and climate change regulation. It's time to protect the soils of Europe.

Thanks for being interested