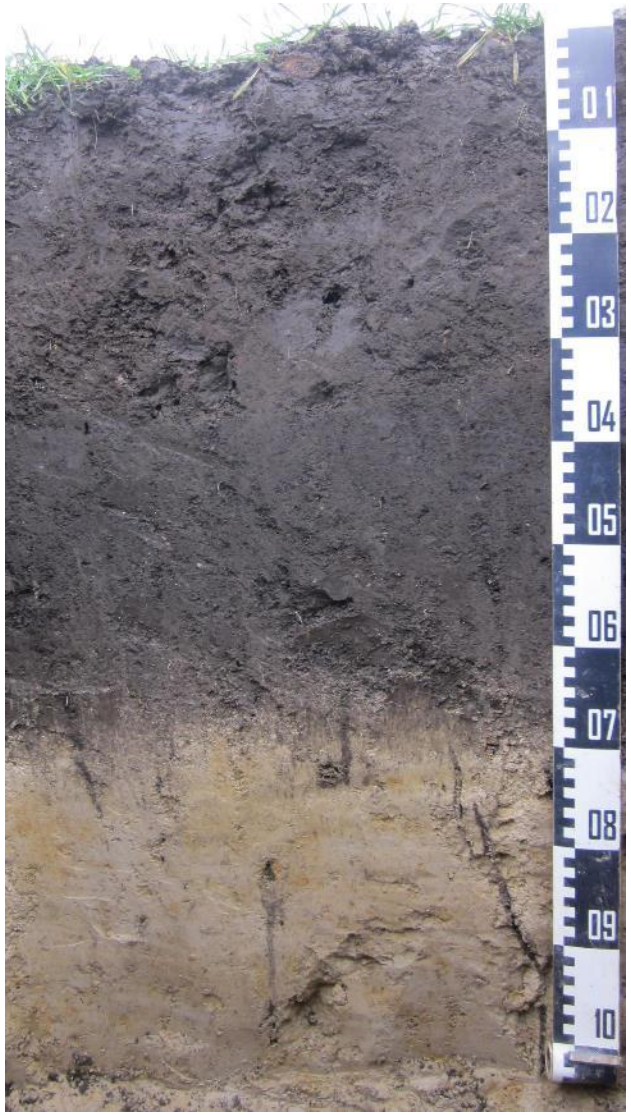

Food and Agriculture Organization of the United Nations
Determination of the clay content of soils
25 June 2024
Indicators soil health based on the relation between soil organic matter and clay
Axel Don, Thünen Institute, Germany
THÜNEN
BESOLAN
BELGIAN AND LUXEMBURG SOIL LABORATORY NETWORK
GLOBAL SOIL PARTNERSHIP

Clay: 3%
Sand: 93%
Topsoil pH ($CaCl_2$): 4.7
Topsoil TOC: 2.9%
SOC stock (0-100 cm): 132 Mg ha^{-1}
Plant available water: 58 mm

Podzol

Tschernozem



Clay: 23%
Sand: 4%
Topsoil pH ($CaCl_2$): 7.1
Topsoil TOC: 2.0%
SOC stock (0-100 cm): 213 Mg ha^{-1}
Plant available water : 220 mm

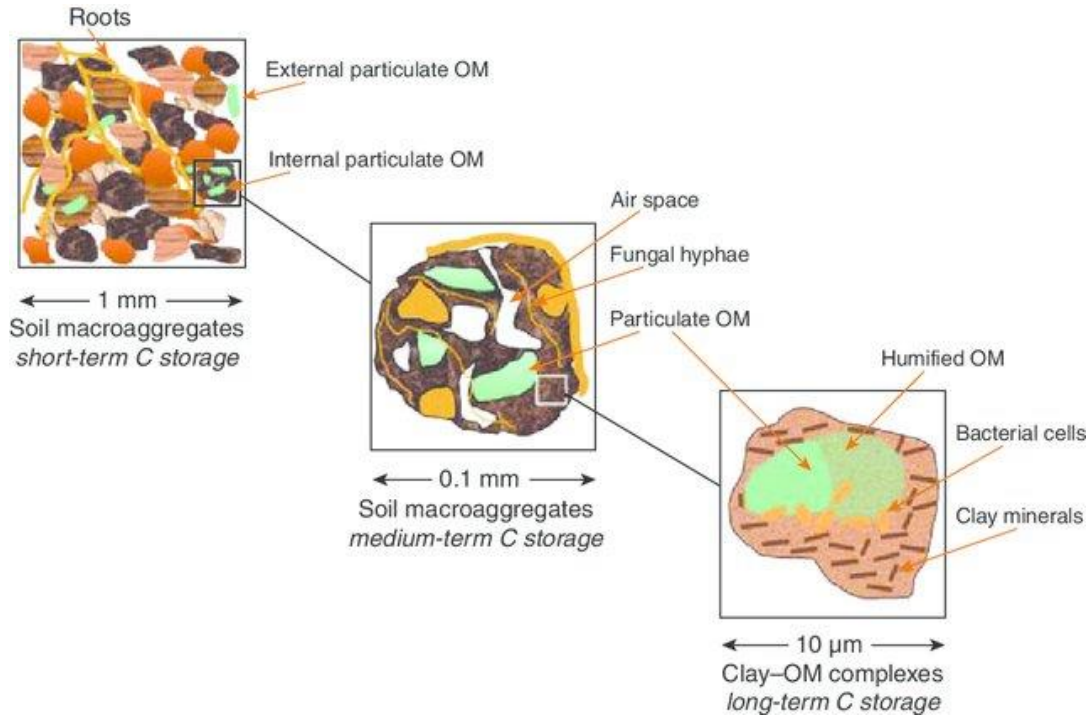
BESOLAN
BELGIAN AND LUXEMBURG SOIL LABORATORY NETWORK

THÜNEN

GLOBAL SOIL PARTNERSHIP

Clay content – a central soil property

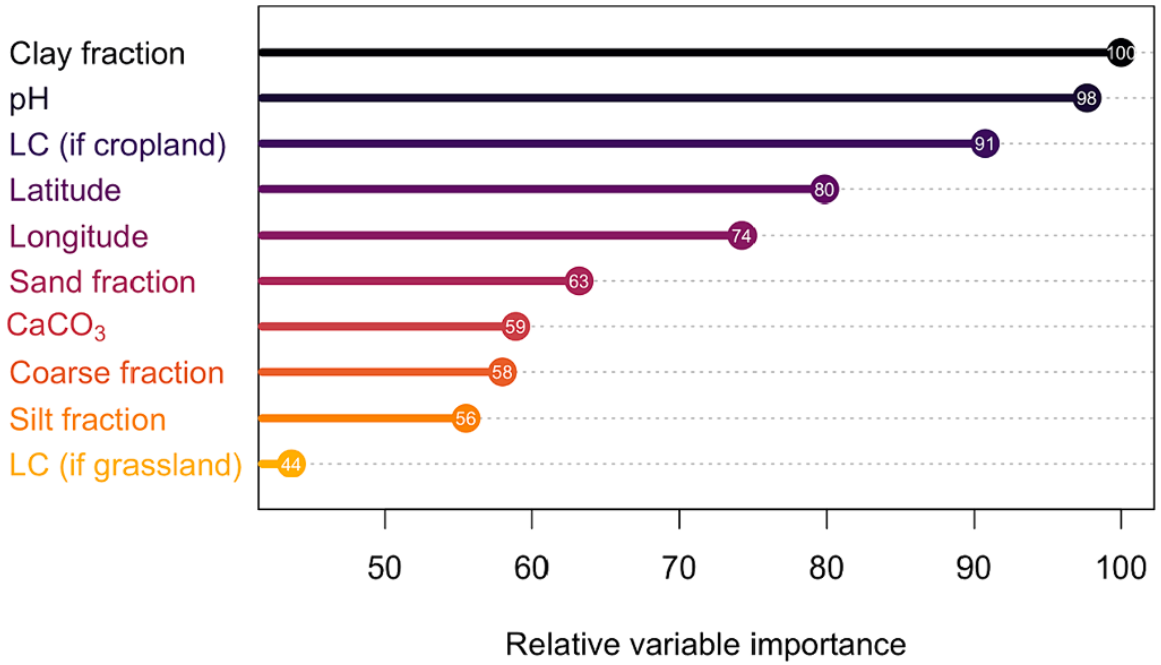
- is hardly affected by land use or climate
- is result of pedogensis and bedrock
- is pivotal for the water retention function of soil
- is essential for soil carbon stabilisation



Eyles *et al.* 2015, Soil Res.

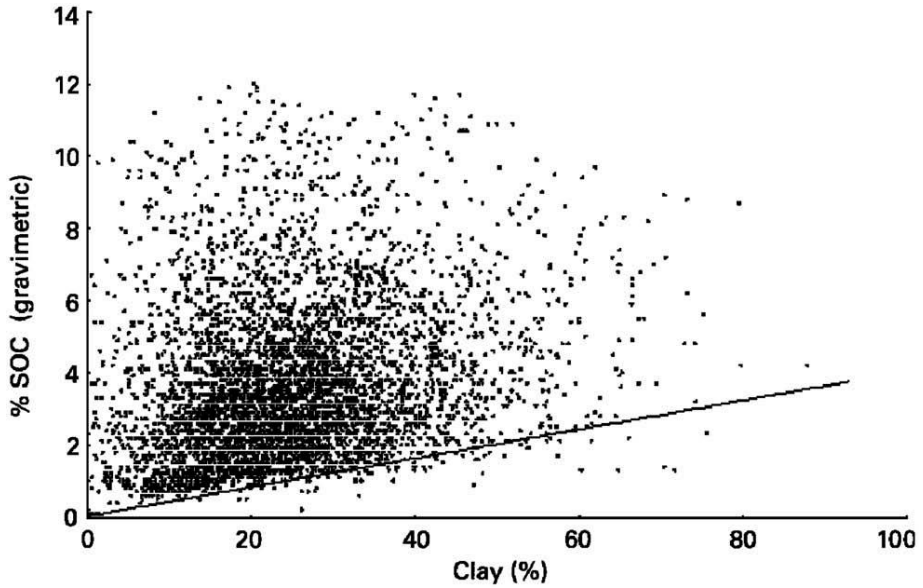
Clay in relation to soil organic carbon

Model predicting soil carbon at European scale



Mäkipää *et al.* 2024, Geoderma

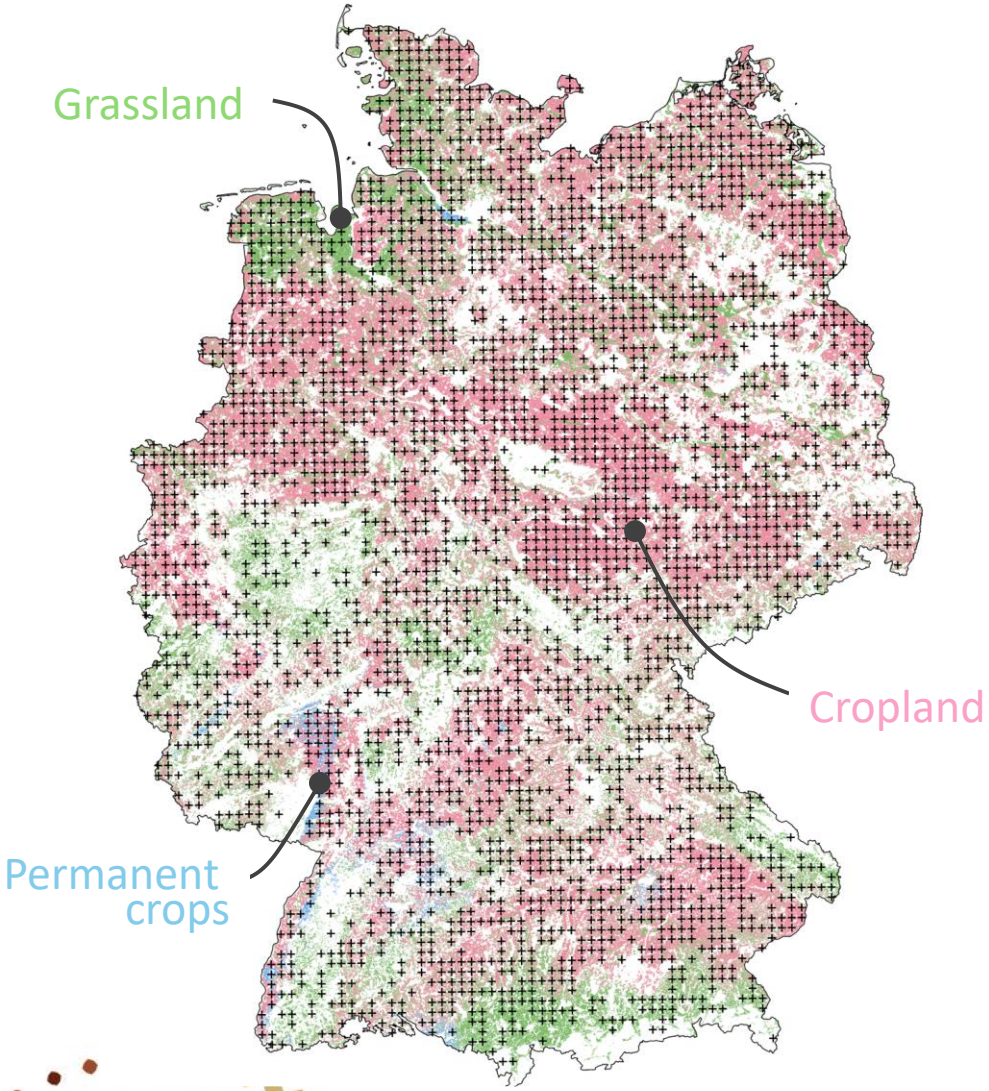
Relation between SOC and clay for Engalnd and Wales



Webb *et al.* 2003, SSSAJ

- Clay is main predictor for soil carbon at large scale
- Clay defines a lower limit for SOC

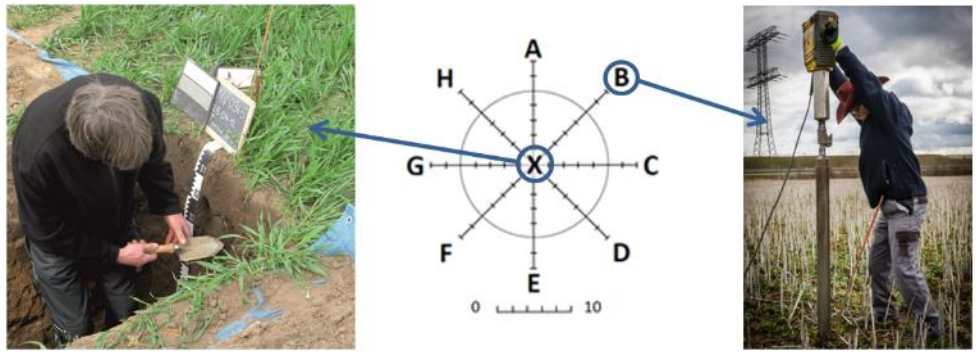
Soil inventories. e.g. in Germany at national scale



- Sampling grid of 8 × 8 km (3104 sites)
- Uniform depth increments:

  0-10, 10-30, 30-50, 50-70, 70-100 cm
- 124.000 soil samples
- Firt completed inventory: 2012-2018
- Data are open access available:

  https://doi.org/10.3220/DATA20200203151139



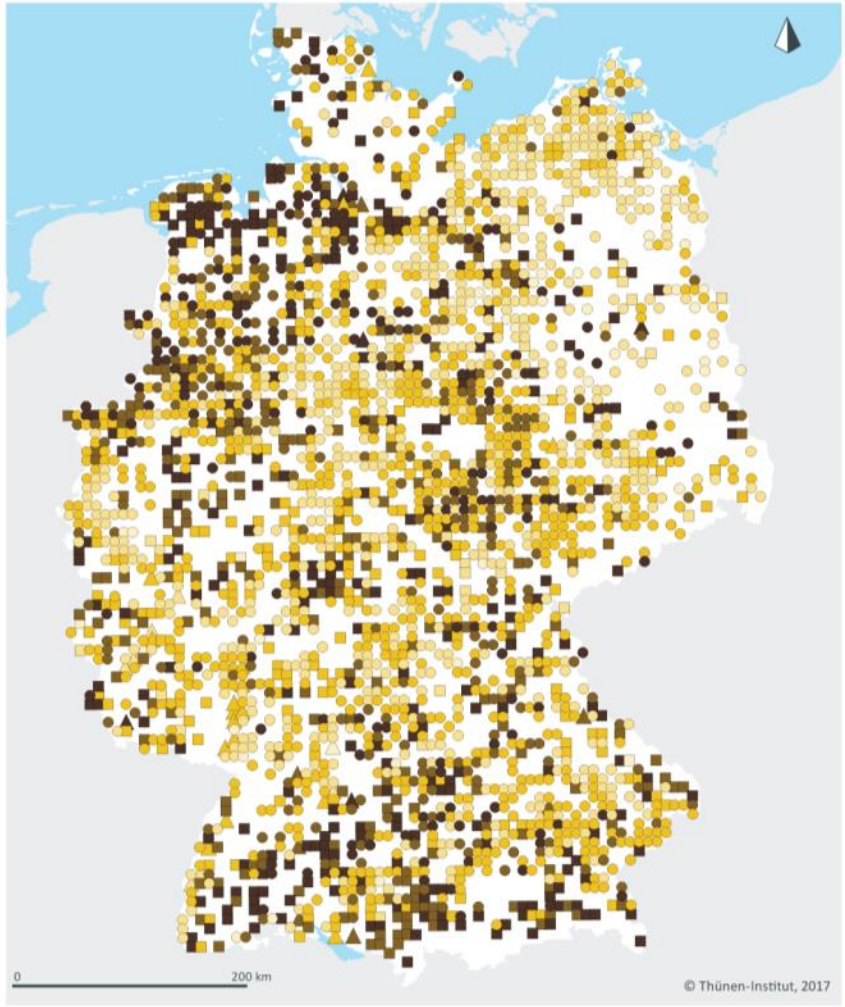
BESOLAN
BELGIAN AND LUXEMBURG SOIL LABORATORY NETWORK

THÜNEN

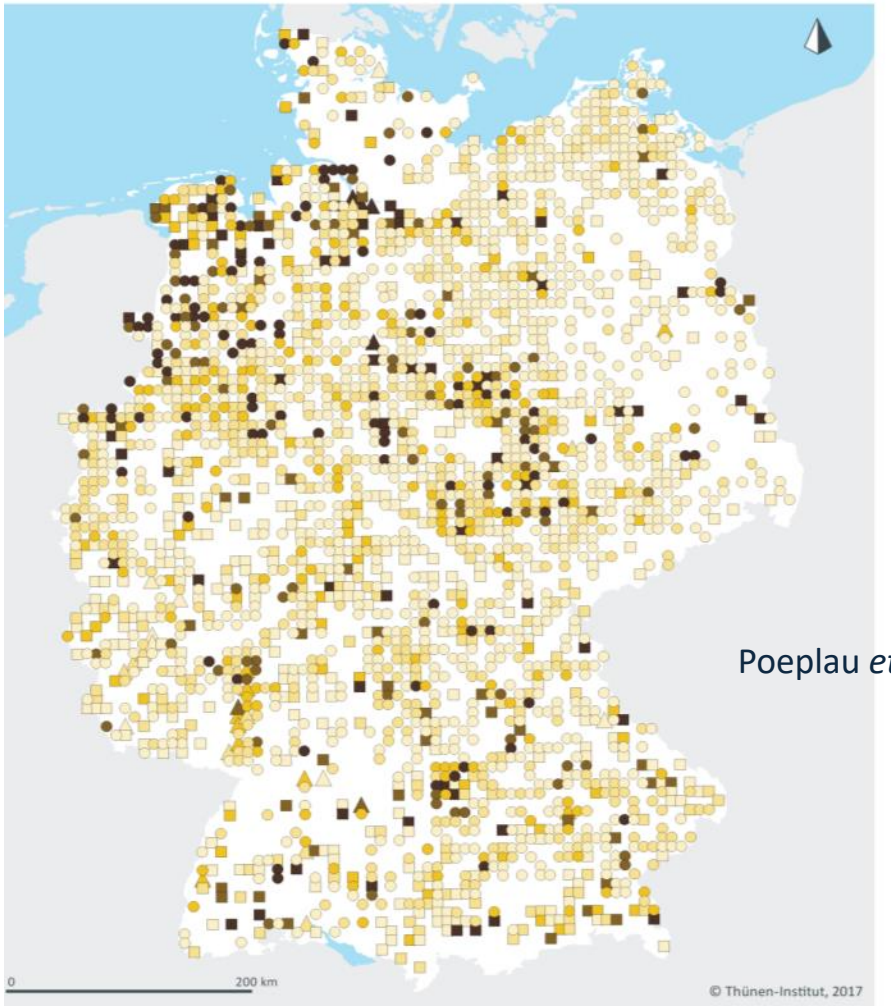
GLOBAL SOIL PARTNERSHIP

Soil organic carbon in Germany

Topsoil (0-30 cm)

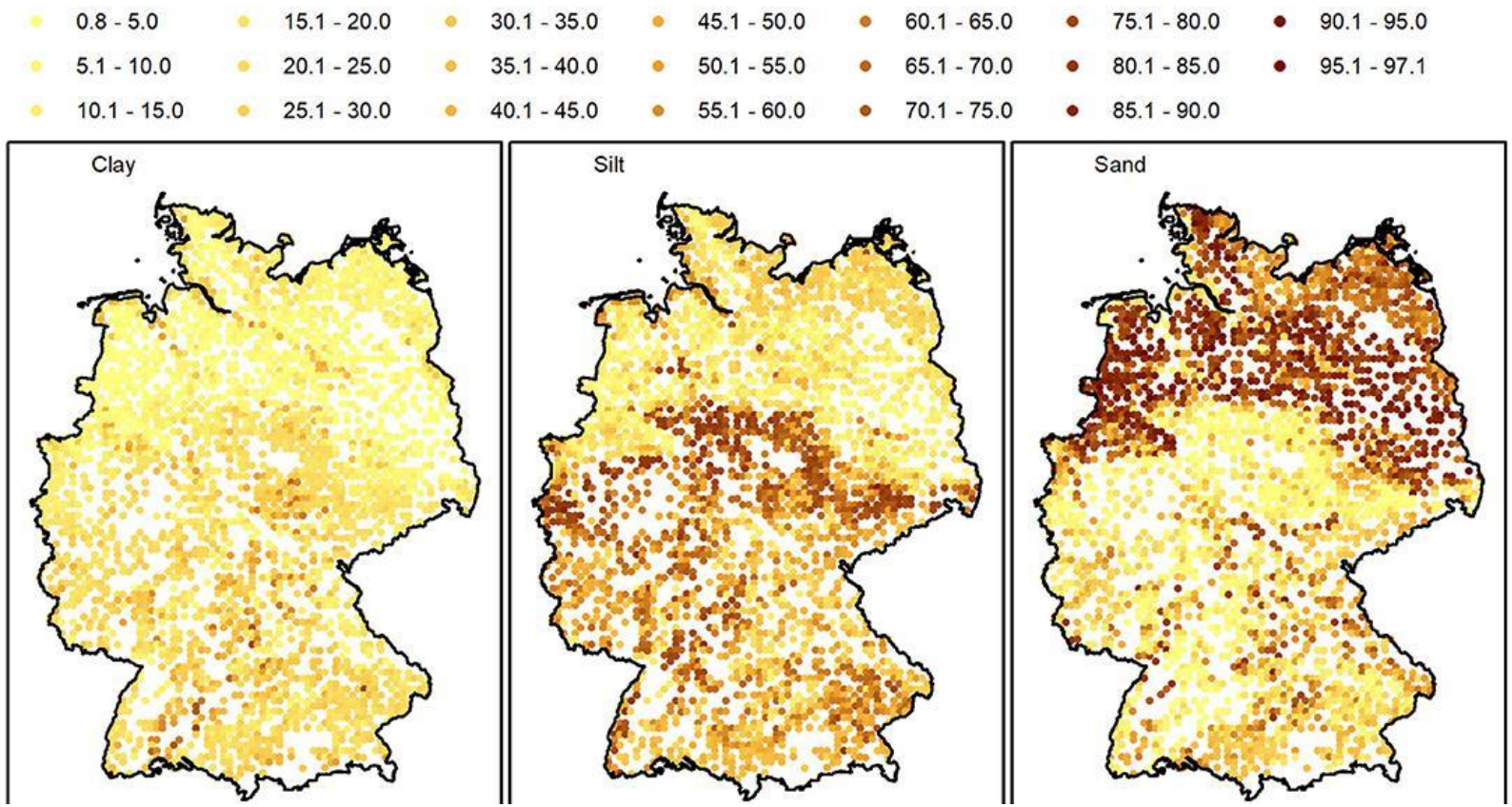


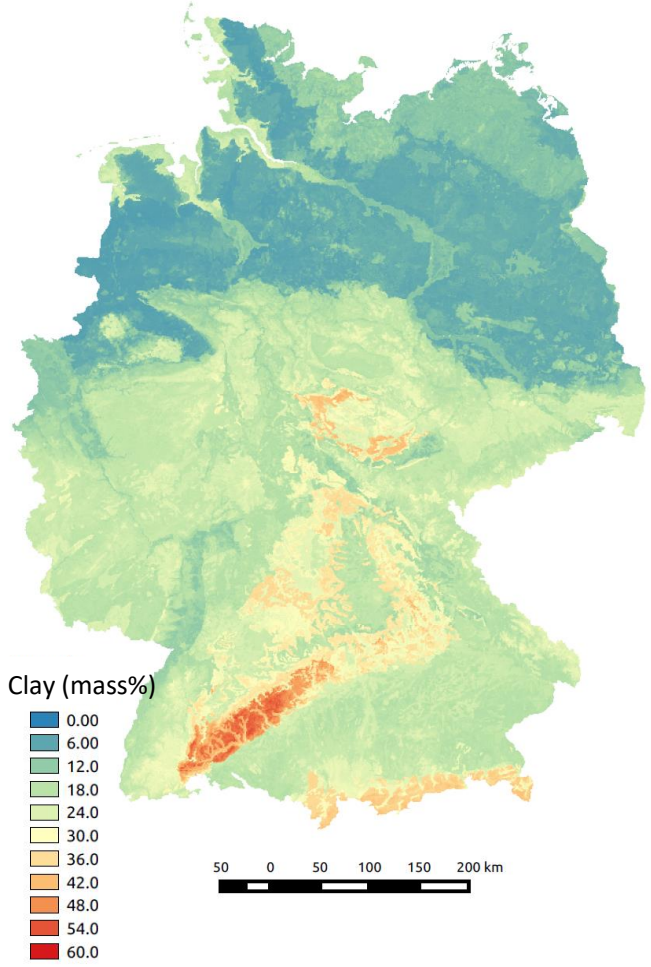
Subsoil (30-100 cm)



Poeplau *et al.* 2020, JPSS

Soil texture in Germany

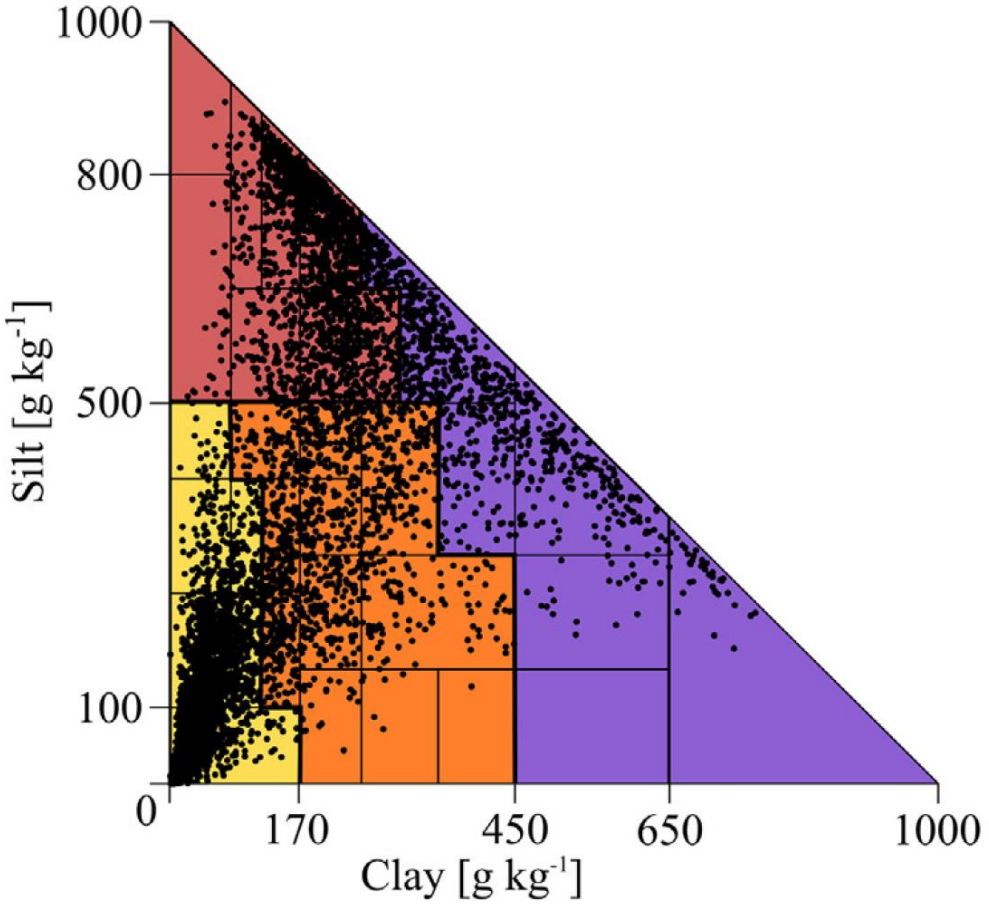




Gebauer *et al.* 2022, Frontiers Soil Sc.

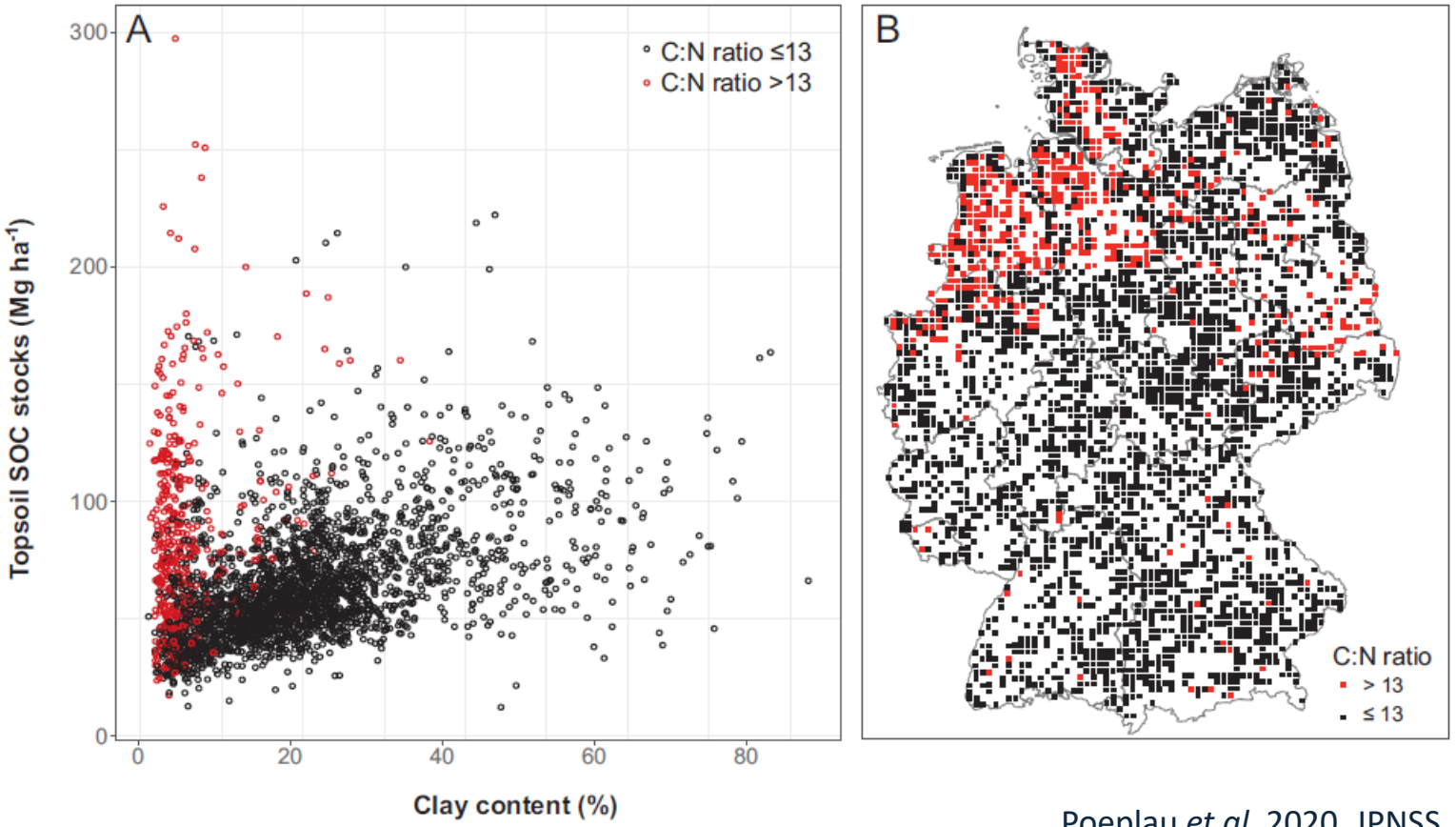
- Clay is less variable than SOC

Soil texture in agriculture



- Distribution of agriculture in Germany across texture classes is uneven
- Soil texture: The standard soil parameter with the most time consuming analytics.

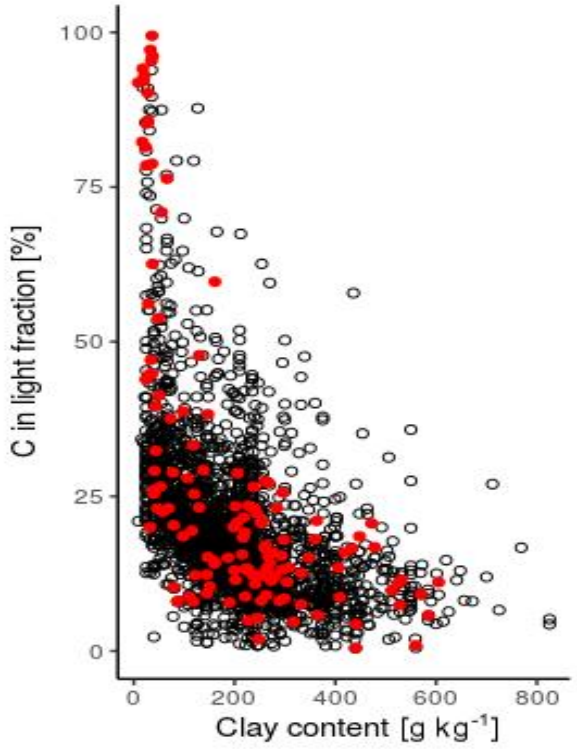
Texture and C/N ratio



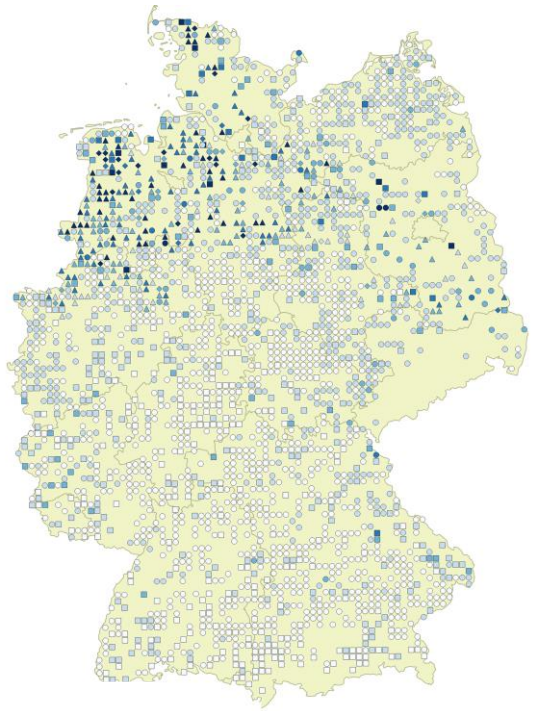
Poeplau *et al.* 2020, JPNSS

- Clay is closely related to SOC
- **Exception:** Some sandy soils, former heathlands and peatlands (C/N>13)
- So called **Black sands** can be found also in The Netherlands and Denmark

Clay and SOC-fractions

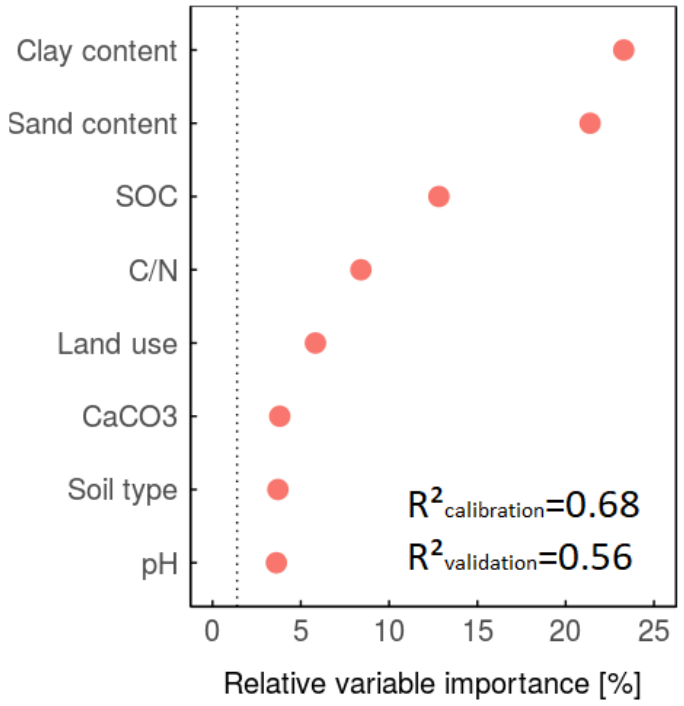


Particulate organic carbon fraction across Germany



Vos *et al.* 2018, SOIL

Driver importance to predict particulate organic carbon



- Clay content determines the fraction of particulate organic carbon (light fraction)

Podzol

Clay: 3 mass%
Sand: 93 mass%
Topsoil pH ($CaCl_2$): 4.7
Topsoil TOC: 2.9%
SOC stock (0-100 cm): 132 Mg ha^{-1}
Plant available water: 58 mm

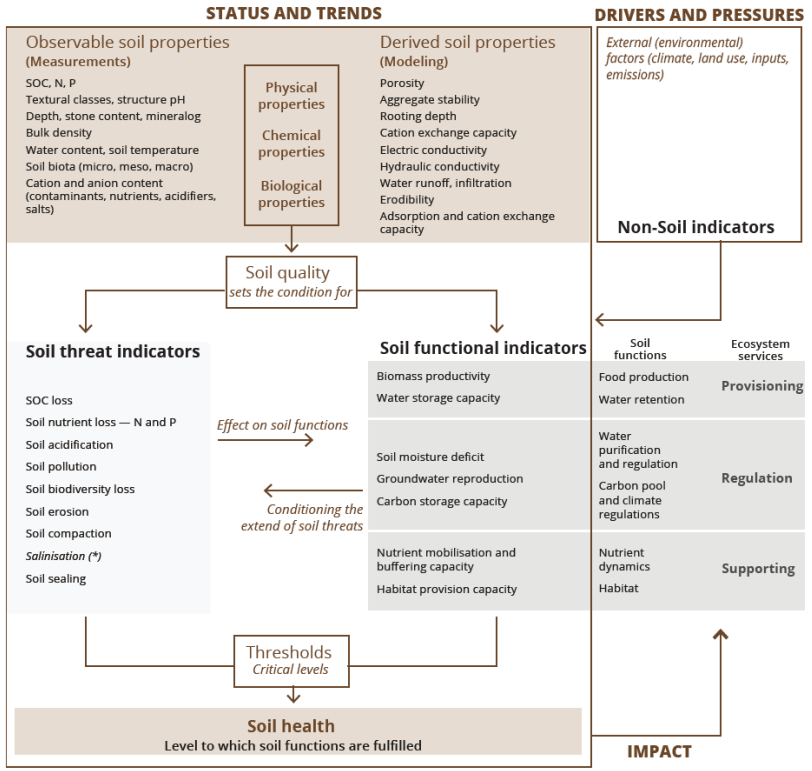
Tschernozem

Clay: 23 mass%
Sand: 4 mass%
Topsoil pH ($CaCl_2$): 7.1
Topsoil TOC: 2.0%
SOC stock (0-100 cm): 213 Mg ha^{-1}
Plant available water : 220 mm

Are these soils in healthy conditions or degraded?

Soil health indicators

- Should be **sensitive** to land management and climate (in contrast to soil quality indicators)
- Should be **relevant** due to its relation to soil functions
- The indicator should be measurable with reasonable effort (**accessibility**)
- Should inform land managers and policymakers

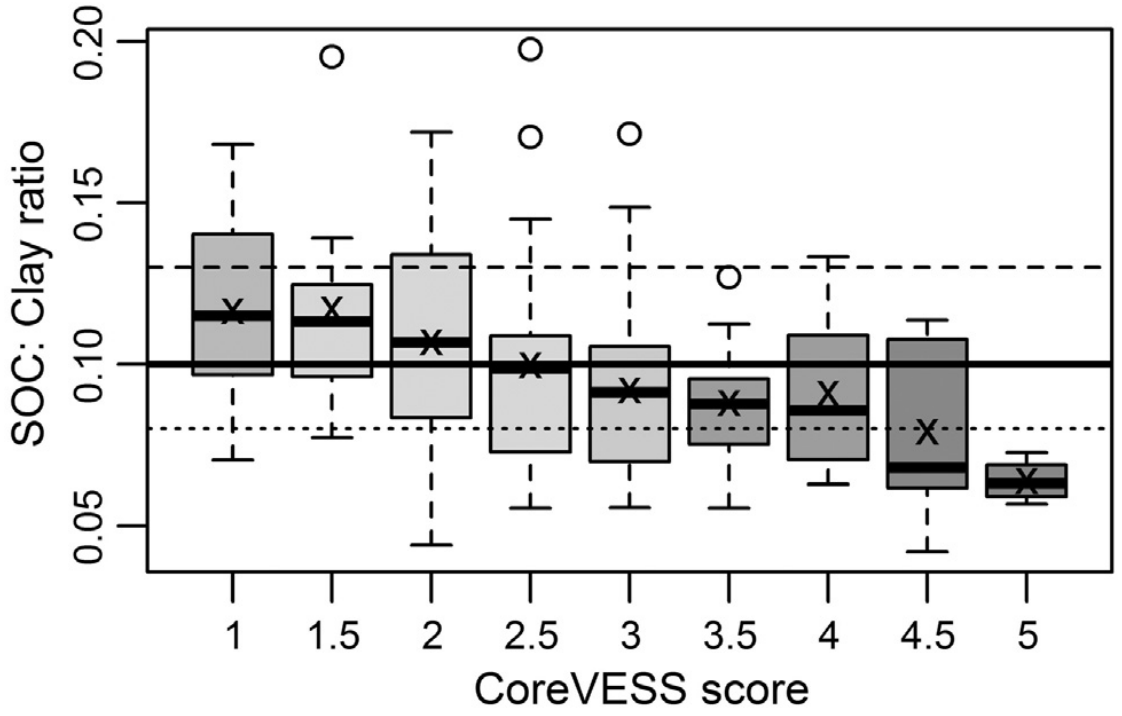


BESOLAN
BELGIAN AND LUXEMBURG SOIL LABORATORY NETWORK

THÜNEN

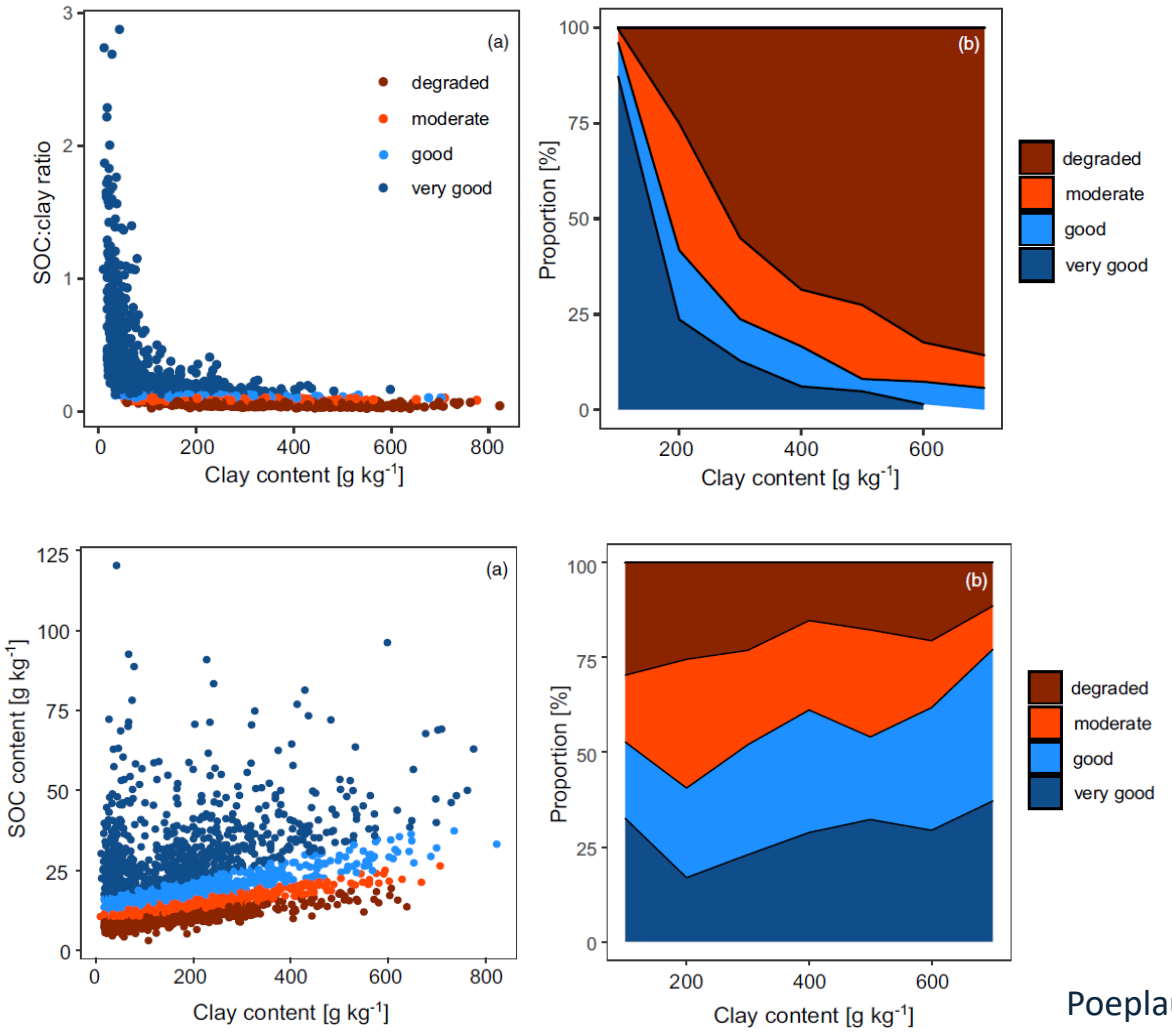
SOC/clay ratio as indicator

- Attempt to turn SOC levels into a soil health indicator
- Normalisation for clay as main SOC driver
- Clear relation of SOC/clay to soil physical parameters



Johannes *et al.* 2017, Geoderma

SOC/clay ratio as indicator



- We applyed SOC/clay ratio to 2958 agricultural soils in Germany
- Almost all clayey soil were „degraded“
- Almost all sandy soils were „very good“
- Normalisation with clay is too strong
- We propose an alternative ratio:

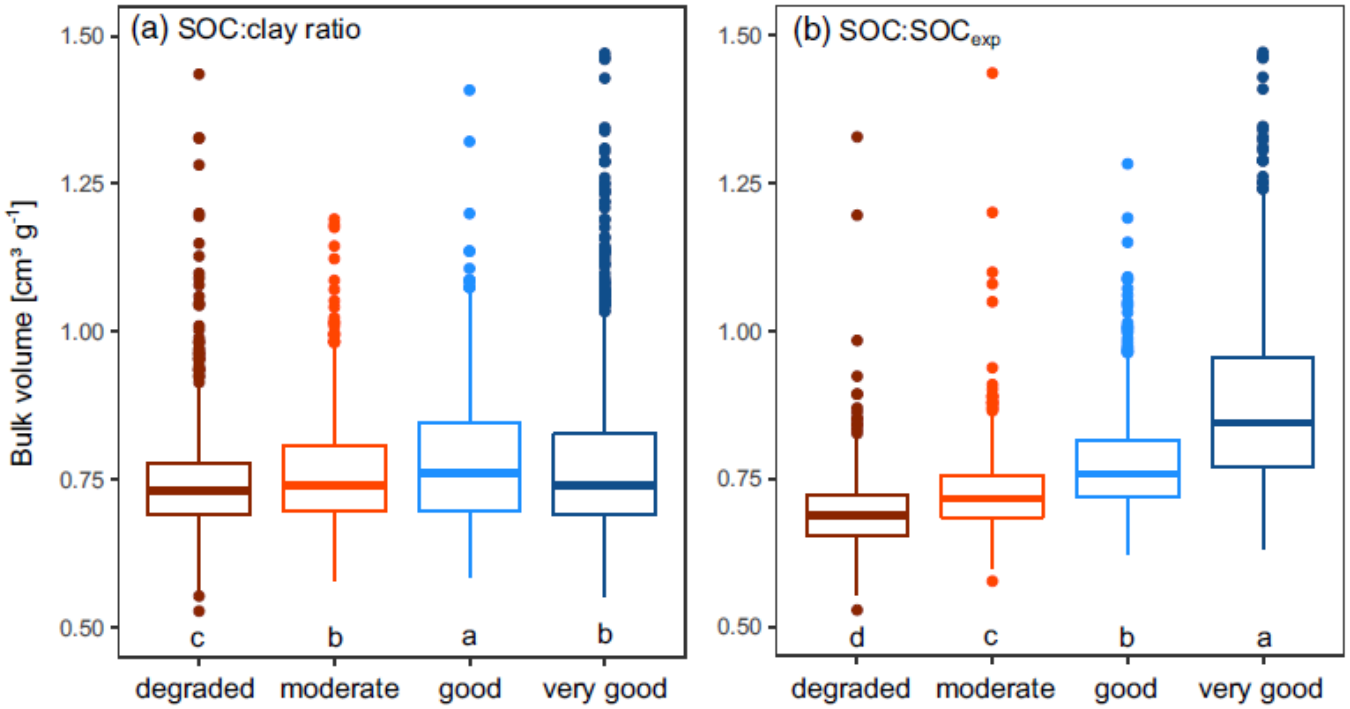
$$SOC/SOC_{exp}$$

With SOC_{exp} as the expected SOC content using a SOC~clay regression/model

Poeplau and Don, 2023, Soil use manag

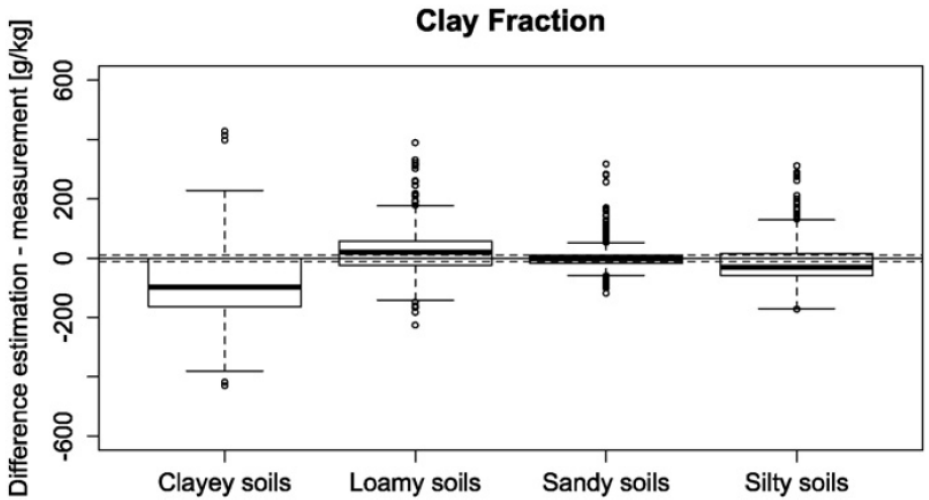
SOC/SOC_{exp} indicator for soil structure

- SOC/SOC_{exp} can better predict soil porosity than SOC/clay
- SOC/clay should not be used as soil health indicator



Poeplau and Don, 2023, Soil use manag

Clay lab analysis vs. texture by feel



3896 soil samples
from 728 soil profiles

Vos *et al.* 2016, Geoderma

- Texture by feel analysis (estimation) by trained soil scientists has surprisingly high precision compared to lab measurement (measurement)
- It can substitute time consuming lab analysis in some cases

Conclusions

- Clay is a key parameter for soil quality
- Clay and soil carbon are closely linked
- Also soil carbon quality is related to soil texture
- SOC/clay ratio is a biased indicator for soil health
- Clay content need to be accounted for to differentiate between managable (soil health) and static (soil quality) soil parameters.

Food and Agriculture Organization of the United Nations

Thank you

GLOBAL SOIL PARTNERSHIP

BESOLAN
BELGIAN AND LUXEMBURG SOIL LABORATORY NETWORK

THÜNEN