Finnish Agricultural Soil Monitoring

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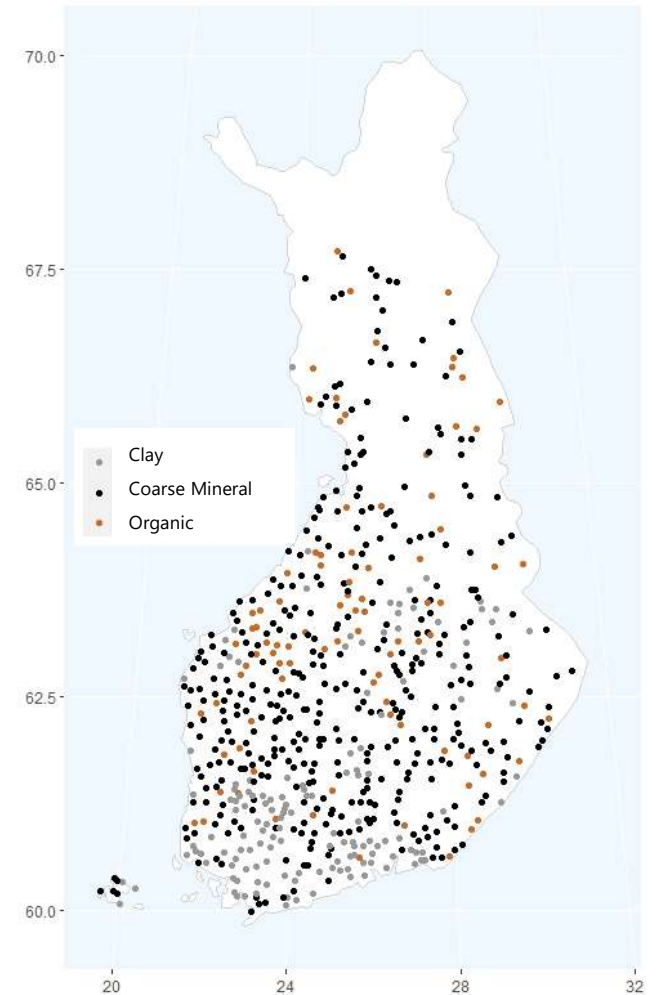
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- First nationwide sampling in 1974
  - 2042 sampling plots growing timothy (*Phleum pratense*)
- Sampling repeated in 10-year intervals
- Number of sampling plots has varied

Year	Number of samples
1974	2042
1987	1362
1998	720
2009	611
2018	631

- Changes in resources
- Plots not actively cultivated have been excluded
- In 2018 sampling, 150 new plots were included resulting in 631 sapling plots

- In 2009 and 2018 all coordinates determined with GPS
- Sampling network covers the whole country except for the most northern part of the country with a small area of cultivated soils
  - In Finland, c. 2 million ha cultivated soil, of which 10-12% are organic soils

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Sampling

- Composite samples (c. 0.5 dm^3) from the 0-15 cm surface layer, sampling area 10 m × 10 m
    - pH and EC (H$_2$O)
    - TOC
    - Ammonium acetate-acetic acid (AAAc , pH 4,65) extractable nutrients (P, Ca, Mg, K...)
        - Basic soil fertility test used in Finland, required from farmers (every 5th year) committed to environmental subsidies (approx. 95% of the area under cultivation)
    - AAAc-EDTA extraction for microelements (Al, Cd, Co, Cu, Fe, Mn, Mo, Ni, Pb, Zn)
- In 2018
    - 0-40 cm profile samples for TOC and bulk density, 0–5 cm, 5–15 cm,15–25 cm and 25–40-cm soil layers
    - 0.05-0.1 dm^3 subsamples were separated from the 0-15 cm composite sample and stored frozen for DNA extraction and pesticide residue analyses

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Soil chemistry, nutrients and microelements

- Results and trends

    - pH in mineral soils decreasing?

    - Soil test P decreasing except in peat soils

    - Status of micronutrient concentrations stable (1974-2018)

        - Locally, concentrations can be low - monitoring of trace elements and, if necessary, fertilisation is important

    - Sufficient nutrient supply in coarse mineral soils and adequate liming of minerals soils must be ensured
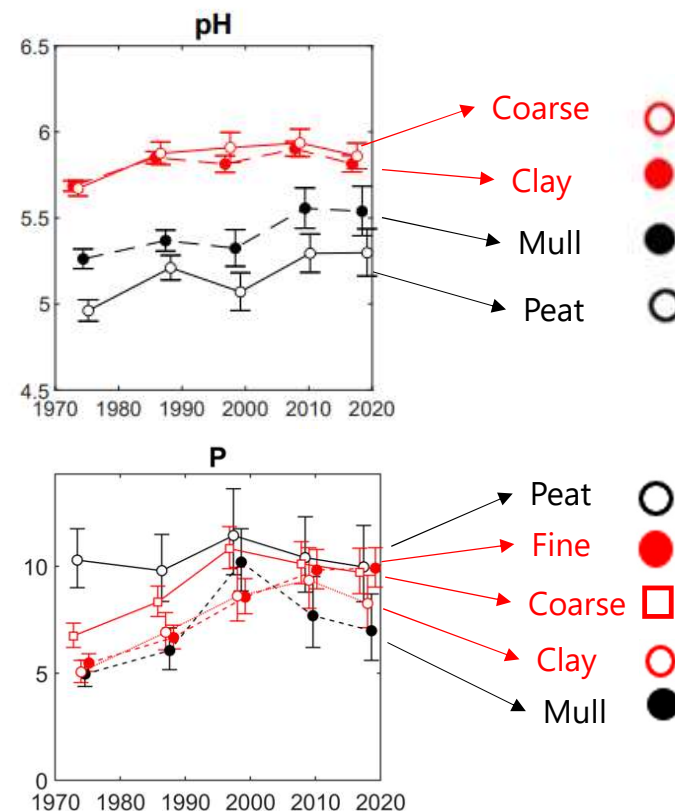
Keskinen, R., Ketoja, E., Heikkinen, J., Salo, T., Uusitalo, R. and Nuutinen, V., **2016**. 35-year trends of acidity and soluble nutrients in cultivated soils of Finland. Geoderma Regional, 7(4), pp.376-387.
Soinne, H., Kurkilahti, M., Heikkinen, J., Eurola, M., Uusitalo, R., Nuutinen, V. and Keskinen, R., **2022**. Decadal trends in soil and grain microelement concentrations indicate mainly favourable development in Finland. Journal of Plant Nutrition and Soil Science, 185(5), pp.578-588.
Haavisto, T. (ed.), **2023**. Suomen maaperän seuranta, tila ja käytön ohjauskeinot: https://julkaisut.valtioneuvosto.fi/handle/10024/165084

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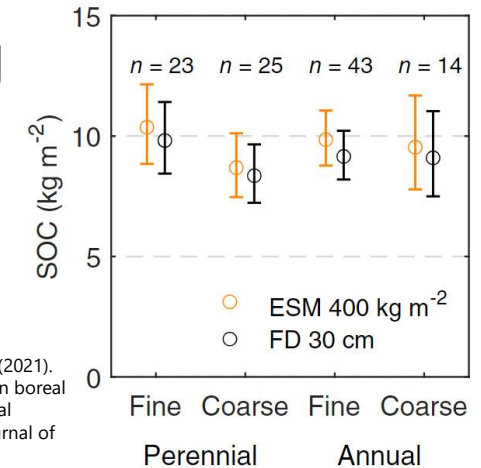Figure from: Heikkinen et al. (2021). Estimation of carbon stocks in boreal cropland soils-methodological considerations. European Journal of Soil Science, 72(2), 934-945.

Soil chemistry, organic carbon

- Boreal agricultural soils are rich in SOC. In mineral soils average SOC stock (0-30 cm) range between 84 and 98 tn C ha^{-1}.

- SOC has decreased almost linearly from 1974 onwards at annual rate of 0.4% (~220kg ha^{-1} yr^{-1}).

- Decrease has been associated with historical land use change, management practices and climate change

Heikkinen et al. (2013). Declining trend of carbon in Finnish cropland soils in 1974–2009. *Global change biology*, 19(5), 1456-1469.
Heikkinen et al. (2021). Estimation of carbon stocks in boreal cropland soils-methodological considerations. *European Journal of Soil Science*, 72(2), 934-945.
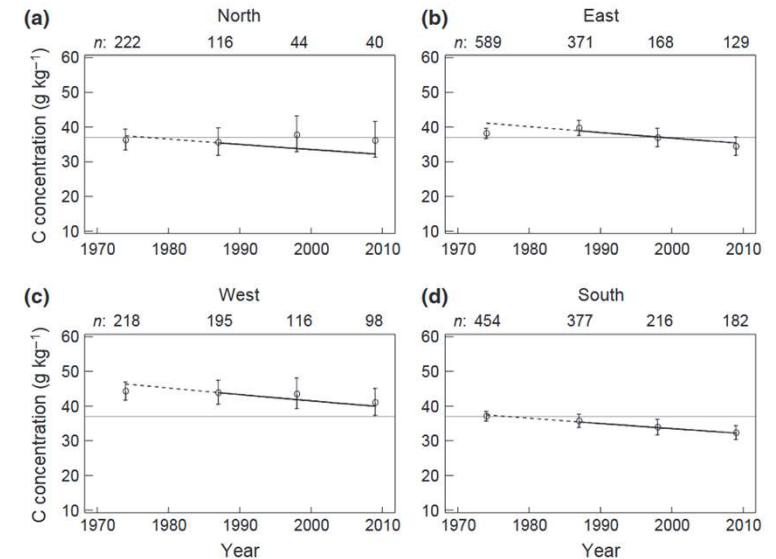**Heikkinen et al.** (2022). Climate change induces carbon loss of arable mineral soils in boreal conditions. *Global Change Biology*, 28(12), 3960-3973.
Kostensalo et al. (2024). Diversification of crop rotations and soil carbon balance: impact assessment based on national-scale monitoring data. *Carbon Management*, 15(1), 2298373.

Figure from: Heikkinen, J. ym. (2013). Declining trend of carbon in Finnish cropland soils in 1974–2009. Global change biology, 19(5), 1456-1469.
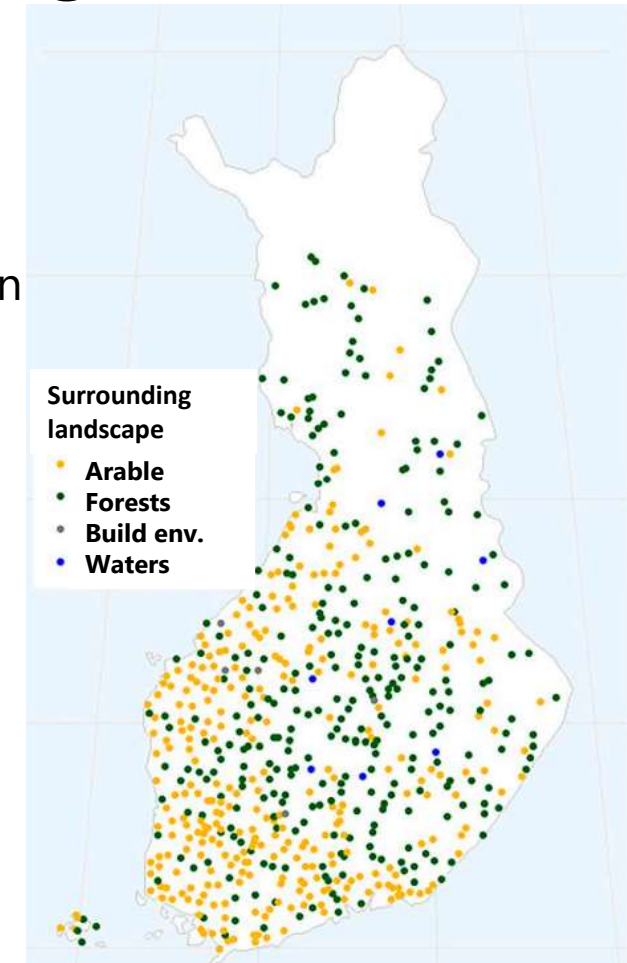
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Soil microbiology

- Samples for DNA extraction (0-15 cm) were taken 2018

- Bacterial and fungal community composition and diversity in relation to climate/region, soil type, surrounding landscape and cropping system

  - Manuscript under preparation (Velmala et al.)

Surrounding landscape
- Arable
- Forests
- Build env.
- Waters
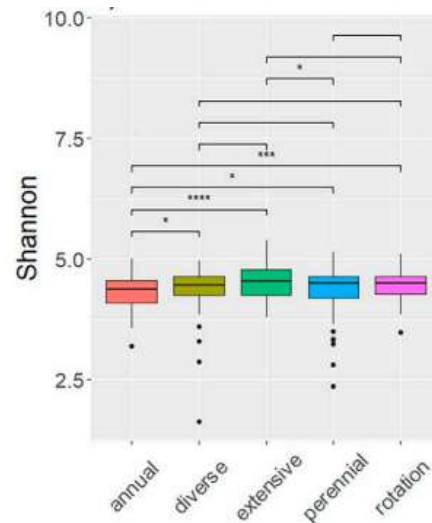
Example of the BioValse –data: Shannon biodiversity index of fungi in the prevailing cropping systems (annual, diverse, extensive, perennial, rotation). The Shannon index takes into account the number of species (richness) and the relative abundance of each species (abundance). A higher value reflects greater diversity.

Figure from: Haavisto, T. (ed.), 2023. Suomen maaperän seuranta, tila ja käytön ohjauskeinot: https://julkaisut.valtioneuvosto.fi/handle/10024/165084

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Pesticide residues

- Of the 2018 collected samples, a set of 148 samples was selected for pesticide residue analysis

- c. 200 pesticide residues were analyzed at Wageningen University, glyphosate and AMPA were analyzed at LUKE

- Manuscript under preparation (Hagner et al.)
    - 30% of the samples contained five or more residues

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Conclusions

- National soil monitoring reveals trends in element contents during the last decades

- National monitoring is essential in monitoring Finnish arable soils as data from farms (soil test data) does not fill strict monitoring criteria, nor is the field-specific data comprehensively available for research

- Next sampling will be conducted around 2028-2030
  - Soil chemistry, including pesticide residues, and microbiology

- More information is needed
  - Soil structure
  - Soil layers below the managed surface layer

Thank you!

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