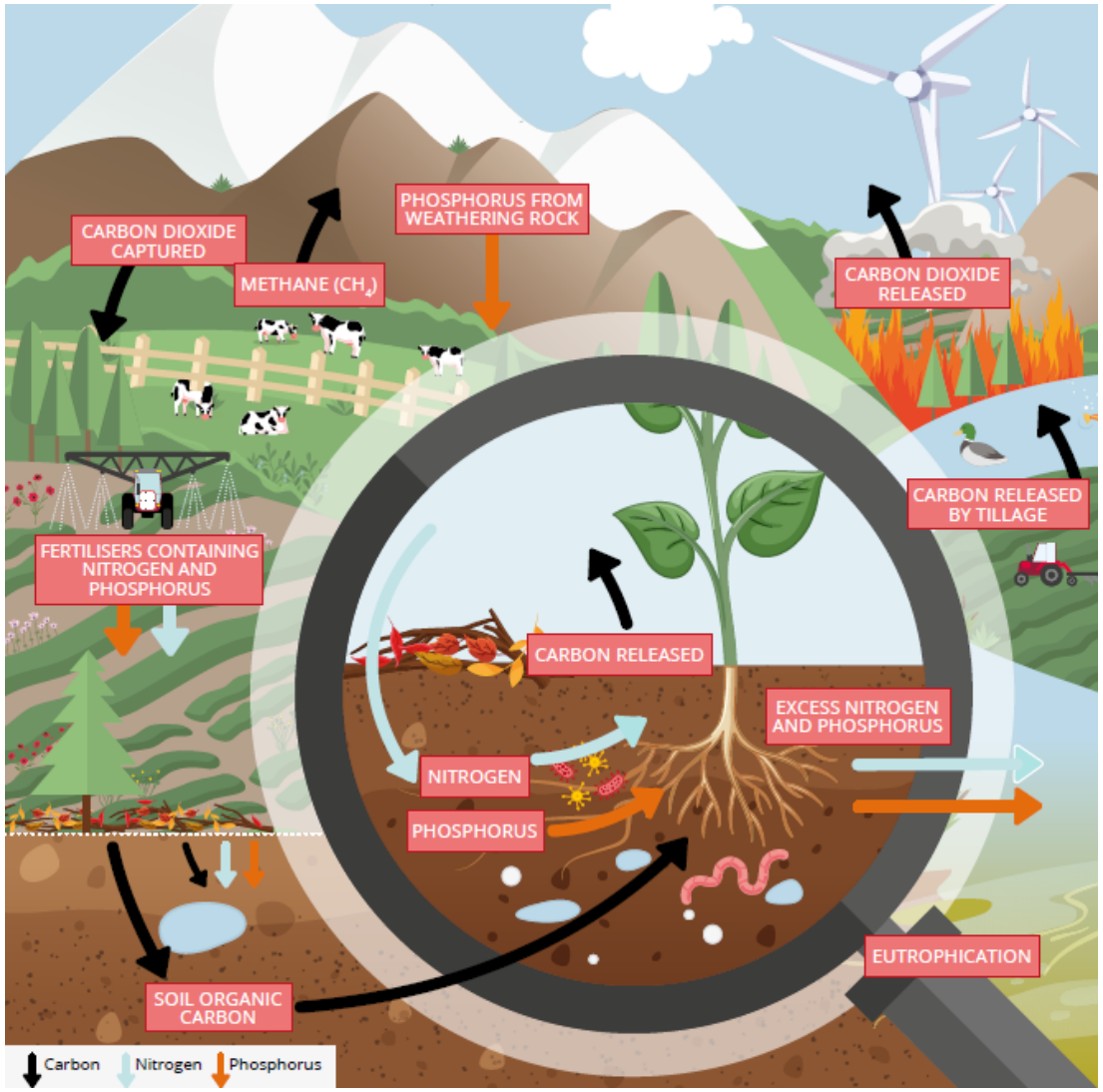
Assessment of soil health

Indicators & thresholds to direct soil restoration

Rainer Baritz |European Environment Agency | 05 December 2022

Healthy soils: enabling resilient ecosystems



- **Food security**: biomass growth (incl. crop yields) depends on **sufficient nutrients and water** in the root sphere of healthy soils.
- **Water provision**: soils with **sufficient organic matter** can hold up to 10-20 times their weight in water
- **Soil biodiversity**: healthy soils provide **sufficient habitat** for a diverse and complex soil food web, able to control potentially harmful organisms

Currently, 60 to 70% of soils in the EU are not in a healthy state

(Veerman et al. 2020)

Healthy soils safeguard sustainable land use

Pest control: natural antagonists

Nutrient storage

Habitat and biological reservoir

Water storage

Filter for contaminants

CO_2 reservoir

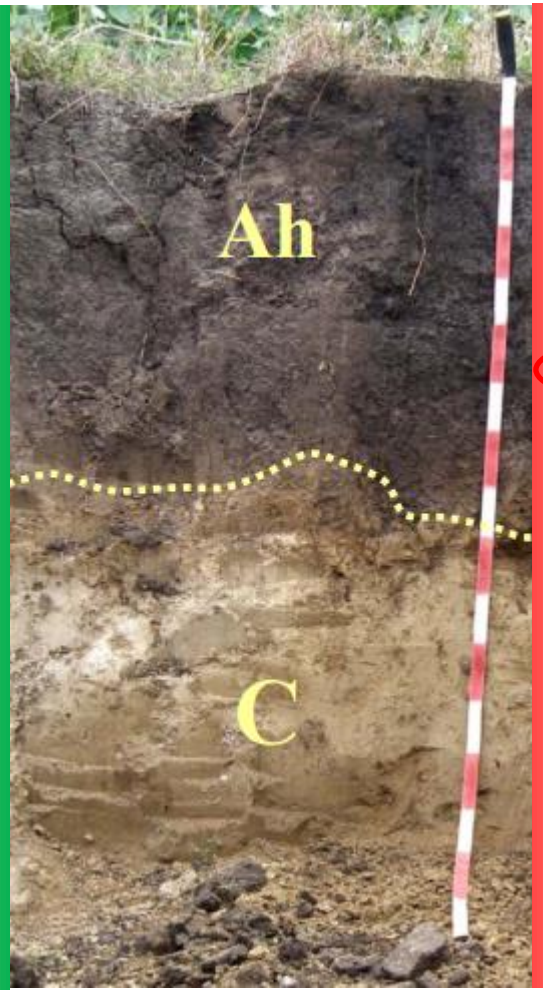


Photo: W. Riek

Degradation of soil functions from unsustainable land use:

Nutrient loss

Mobilization of contaminants

Drought

Erosion

Compaction

Salinization

Biodiversity loss

Carbon loss

Soil functions support ecosystem services

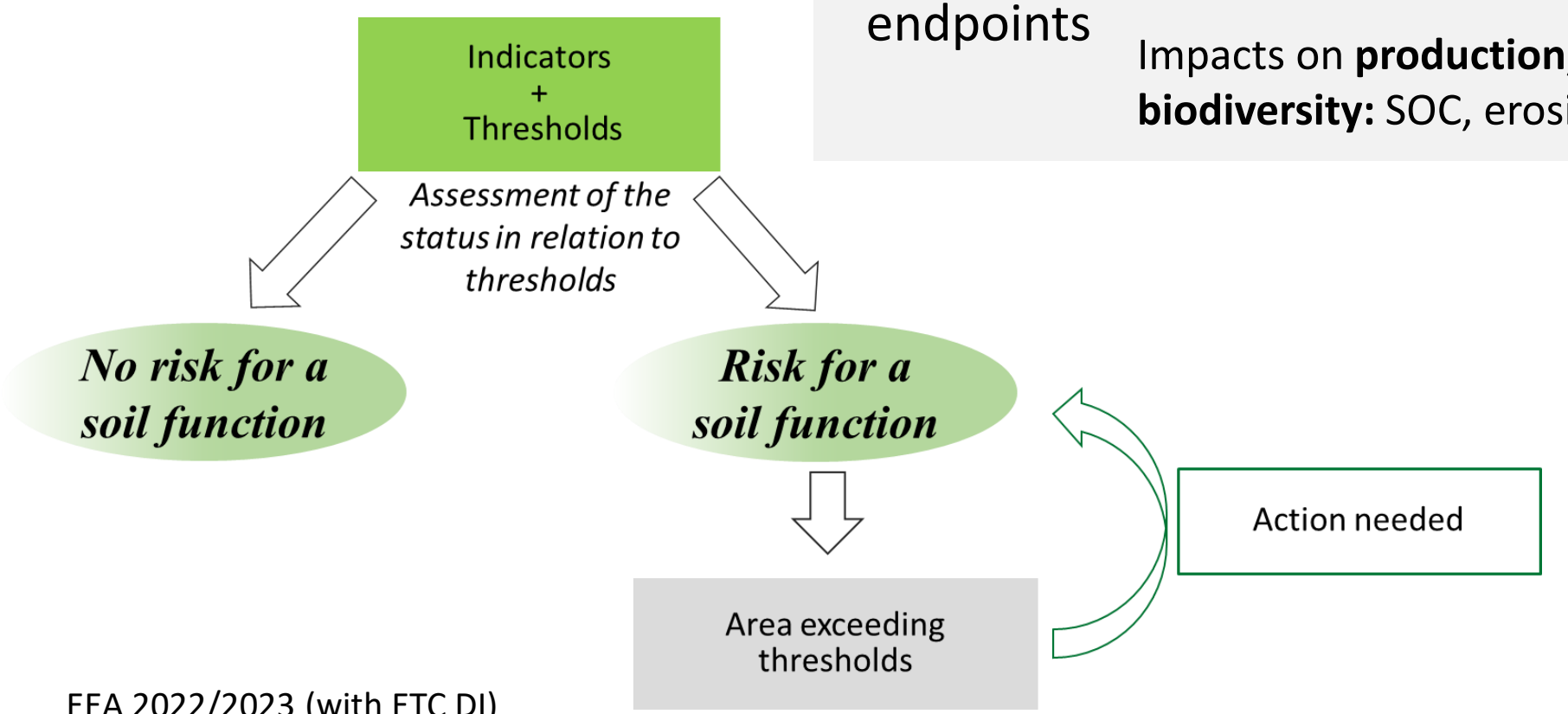
Soil and zero pollution monitoring 2022

	Air pollution and ecosystems	Soil pollution and ecosystems	Freshwater Pollution and Ecosystems	Marine Pollution and Ecosystems
Past Trends	Trends show a mixed picture	Deteriorating trends dominate	Trends show a mixed picture	Trends show a mixed picture
Future Prospects/Distance to Target	Partly on track	Partly on track **Impact of the EU Soil Strategy 2030**	Partly on track	Largely not on track

- There is **significant variation** in the intensity and impact of soil pollution across Europe. There is evidence that **heavy metals and persistent organic pollutants are accumulating** in soils despite decreasing releases from sources such as industry and transport.
- **Levels of copper and zinc in soils exceed safe thresholds.** Inputs are largely related to the application of fertilisers (including manures) and plant protection products.
- Nitrogen surplus in agricultural soils is still widespread. This poses a hazard to the quality of surface and ground waters. Soil acidification is also observed in some areas.

Soil condition in Europe

Approach: protection targets/ endpoints	Impacts on **air and water quality**: nutrients (ammonia: air; nitrate and phosphate: water) Impacts on soil **biodiversity**: heavy metals Impact on **food quality**: cadmium Impacts on **production, water provision, soil biodiversity:** SOC, erosion, compaction



EEA 2022/2023 (with ETC DI)

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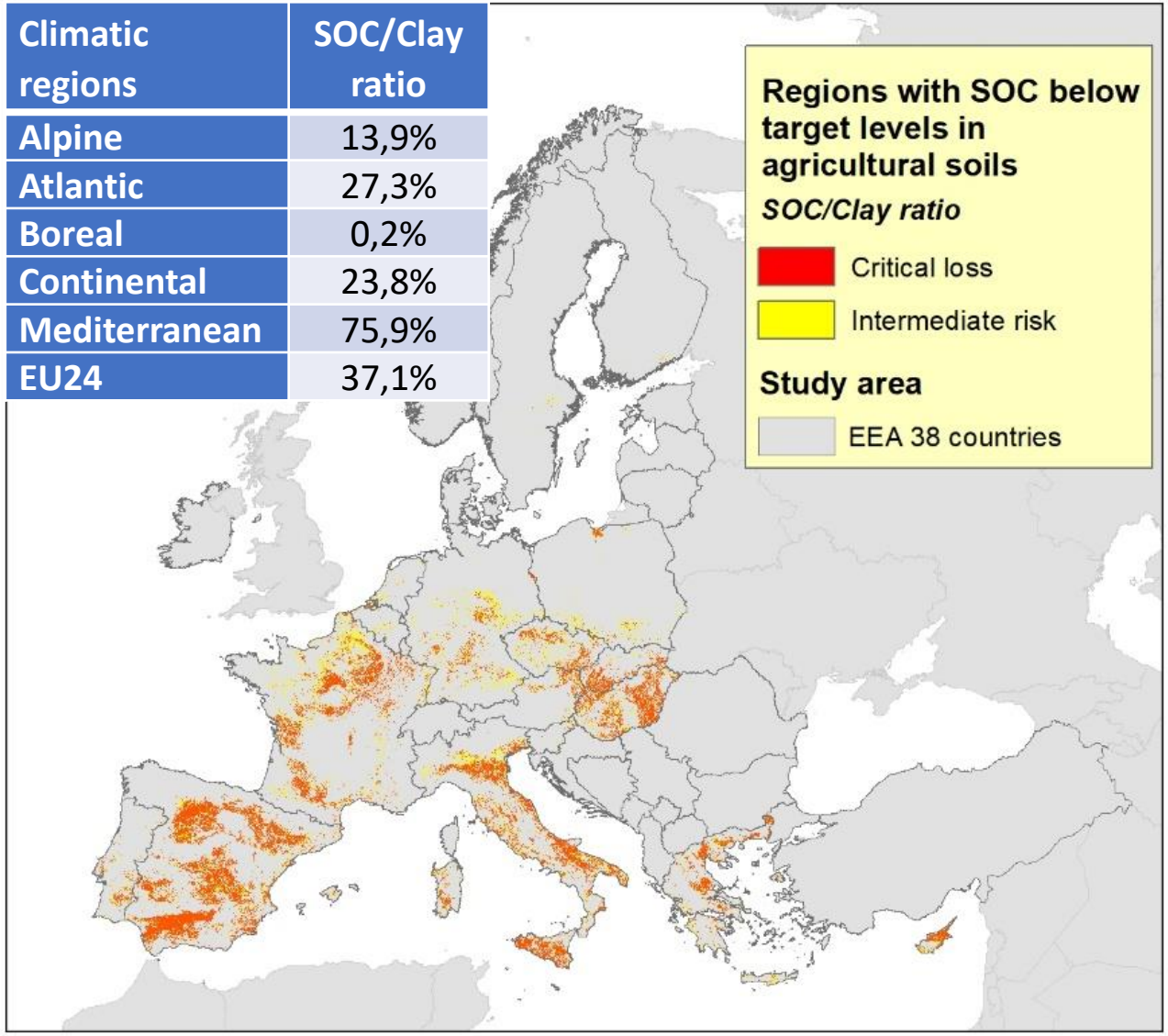
Carbon management

- Carbon sequestration in soils is addressed in the revised LULUCF regulation, the draft Nature Restoration Law (SOC in agroecosystems), and others
- **Functional SOC deficiency** is wide-spread:
  - Long term agricultural field experiments support the SOC/clay ratio as indicator
  - Representativity gaps

Climatic regions	SOC/Clay ratio
Alpine	13,9%
Atlantic	27,3%
Boreal	0,2%
Continental	23,8%
Mediterranean	75,9%
EU24	37,1%



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SOC/Clay = 1:10 Goal for farmers as minimum desired SOC level (vulnerability limit)
SOC/Clay = 1:13 Ratio below which structural soil quality is most likely unacceptable (degradation)

Nutrient management

- Spatially explicit input and output budgets (inputs: fertilizers, livestock numbers, and biosolids (compost and sludge), N fixation, deposition, mineralization) outputs: crop removal, emissions, denitrification, runoff leaching)
- Largest N exceedances and P losses occur in regions with the highest agricultural inputs
- Impact of soil properties: sandy, clayey, organic

Critical inputs are inputs at which critical losses in view of protection targets occur

Thresholds

(i) critical N deposition on natural ecosystems (NH3 emissions)

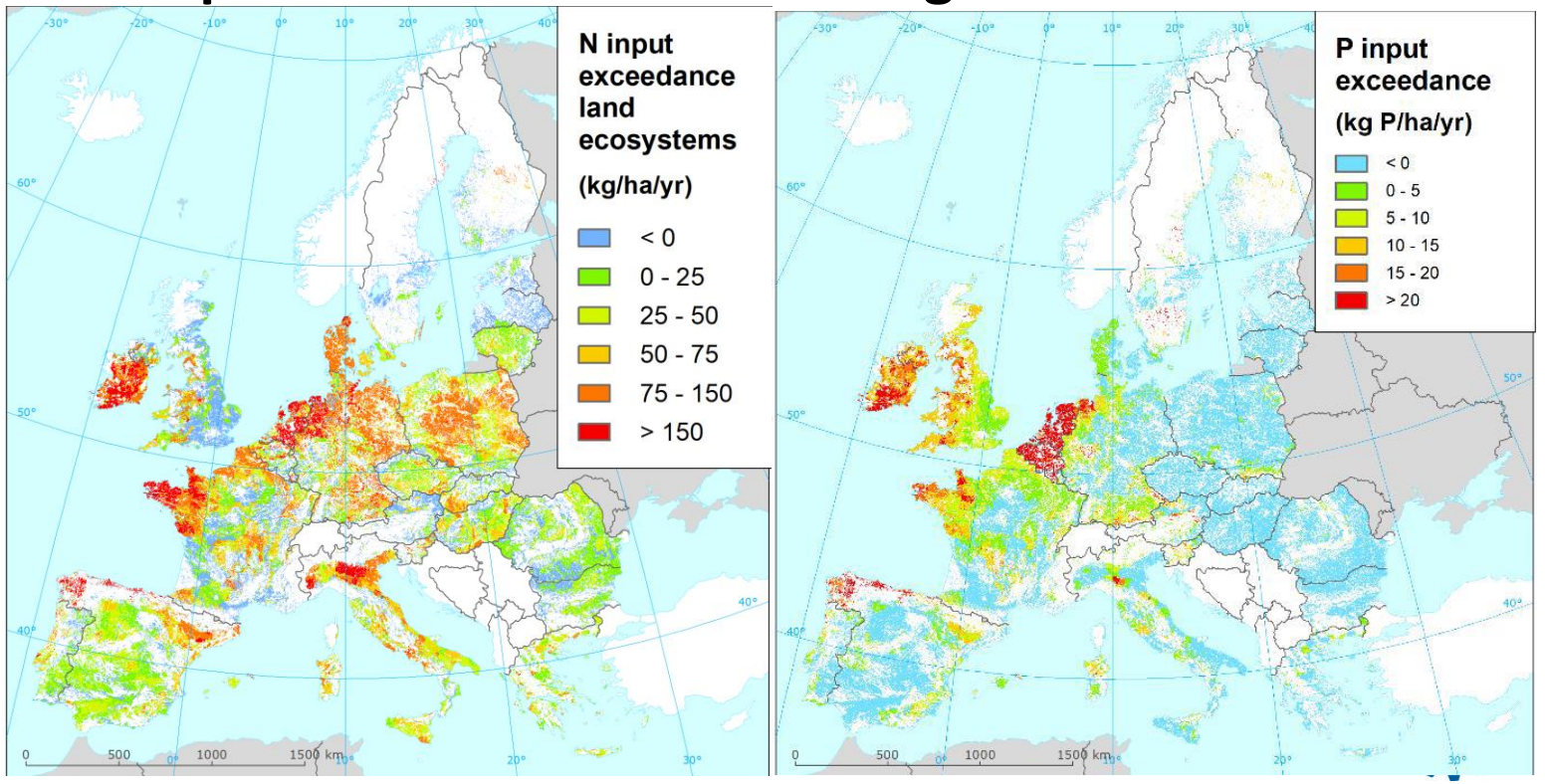
(ii) critical nitrate (NO3) concentration of 50 mg NO3 l-1 in leachate to groundwater

(iii) critical N concentration of 2.5 mg N l-1 in runoff to surface water

(iv) long-term critical P input by fertilizer and manure = P removal by the crop

De Vries et al (2022)

Hotspots of nutrient losses for agricultural soils

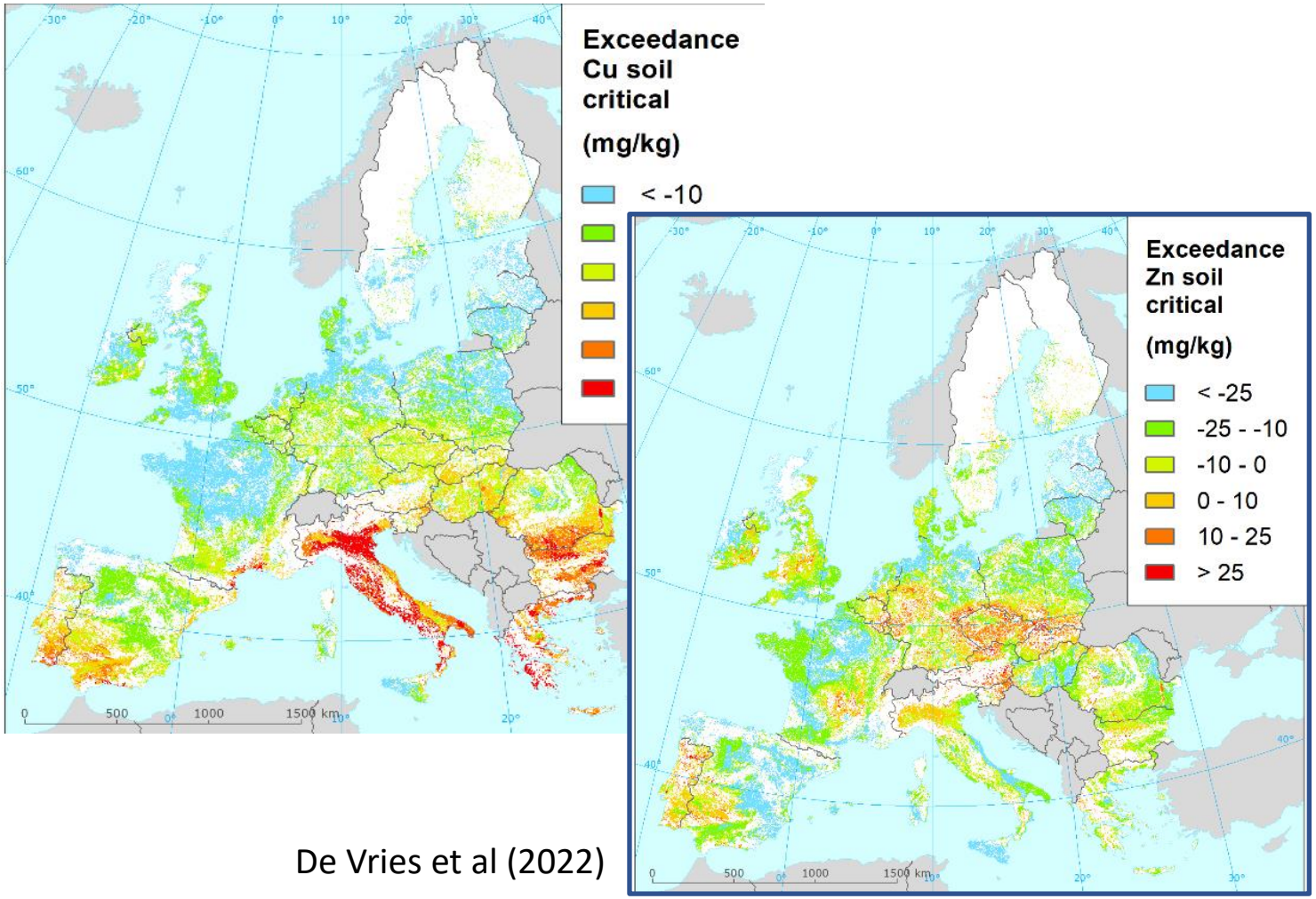


Nutrient management

- **N losses** must **be lowered** by ca. 50 %, in order to fully protect terrestrial and aquatic biodiversity (N losses to air and water to be reduced by 35% (NH3 emissions) and 50% (N runoff)
- **N inputs** would need **to decrease** by similar rates, namely 31% and 43%, respectively

Soil pollution

Critical reactive **metal** concentrations as a function of soil organic matter content (SOM) and pH



De Vries et al (2022)

Main contaminants are

- metals and persistent organic chemicals (POPs)
- antibiotics (waste waters, slurries and sludges)
- microplastics (sewage sludge produced from wastewater treatment plants, sludge-based fertilizes, sludge-composts)

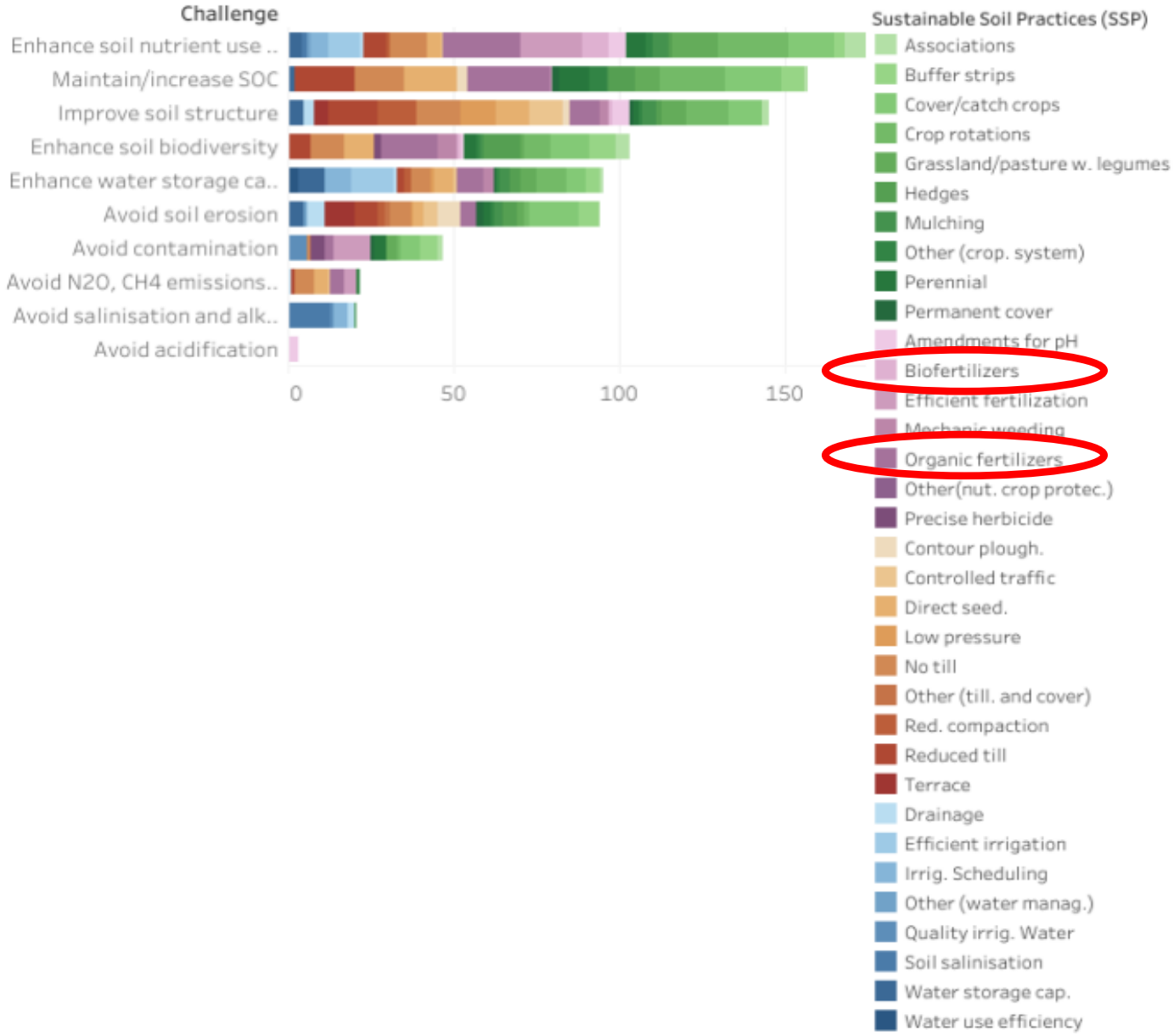
	Metal threshold exceedance	
	Cu	Zn
Arable land (including pasture)	23%	18%

Diffuse pollution from fertilizers and plant protection products

- Soil contaminants reduce crop yield, are taken up by plants and soil organisms, and are released to drinking water sources; soil pollution is estimated to be involved in 15% of pollution-related mortality rates in rich countries (Landrigan et al. 2018).
- In many agricultural soils, **organic pollutants** (e.g. herbicides) are proven to **accumulate**, with still largely unknown risk levels for humans; warnings also include potential cocktail effects
- Besides plant protection products, the use of **mineral and organic fertilizers, compost, digestates and sludges has a strong effect on the quality of soils**. Protection values have been designed in various national legislations
- In a German case study (Koerdel et al. 2007) could prove that **agricultural sludges** can increase pollutants in soils, for some organic pollutants (Benzo(a)pyren und PAK) as well as Cu and Zn. Even if these increases are slight, accumulated effects in soils from repeated application and – in the case of POPs – its persistence in soils – the long-term impact could be significant.
- In a case study in CZ, Agyeman et al. (2021) mapped agricultural soil using a **health index and total carcinogenic risk**; he detected hotspots where immediate remediation would be required (6.1% of the study area with a potential risk to children; 13.05% of the sampled locations are carcinogenic to children).

Responses: Sustainable soil management

- Objective: recommend measures to address soil health:
- Range of options is large
- Site- and farm-specific implementation conditions and options need to be known



Sustainable soil management: role of organic fertilizers

- Naturally available resource (nature-based solution)
- Composts: Improvement of soil structure: increase the ability to hold onto water and nutrients
- Inappropriate application may cause risk such as nitrate pollution
- Offers a carbon source to microbes; tend to increase species diversity
- Gradual release of nutrients; less dependency on mineral fertilizers
- Critical questions: more costly(?), potential for contaminants (?), low nutrient levels

Role of organic farming supported in many ways

- Organic fertiliser trend to rise with organic farming, and this increases in the EU (Eurostats 2022, reporting 2020)
- Demand for organic fertilisers for food, and other uses, to support the growing bioeconomy will increase

Thank you

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