ENVIRONMENTAL ISSUES AND MINE ACTION

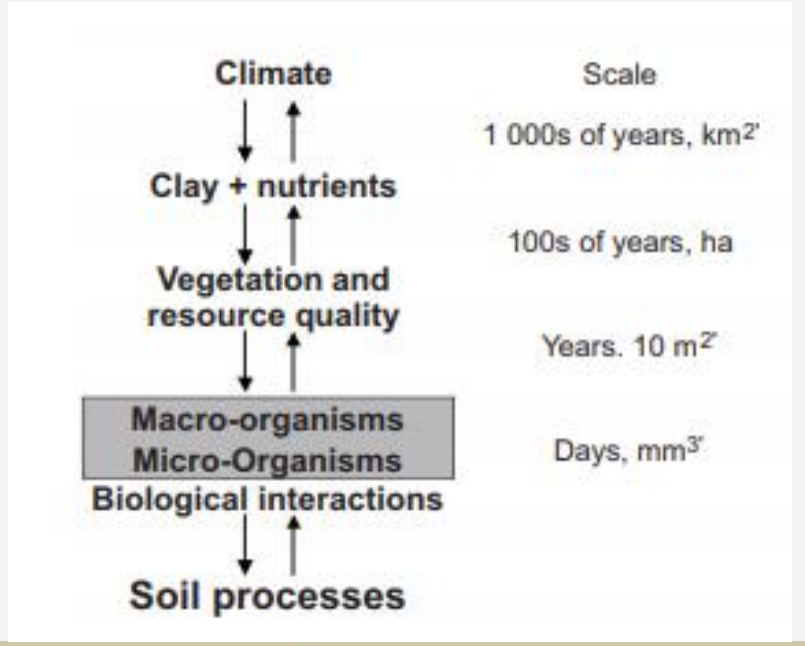
UNDERSTANDING SOIL HEALTH IS MORE THAN REMEDIATION

Royal Agricultural University

Dr Felicity Crotty @collembola

THE STATE OF THE ENVIRONMENT: SOIL

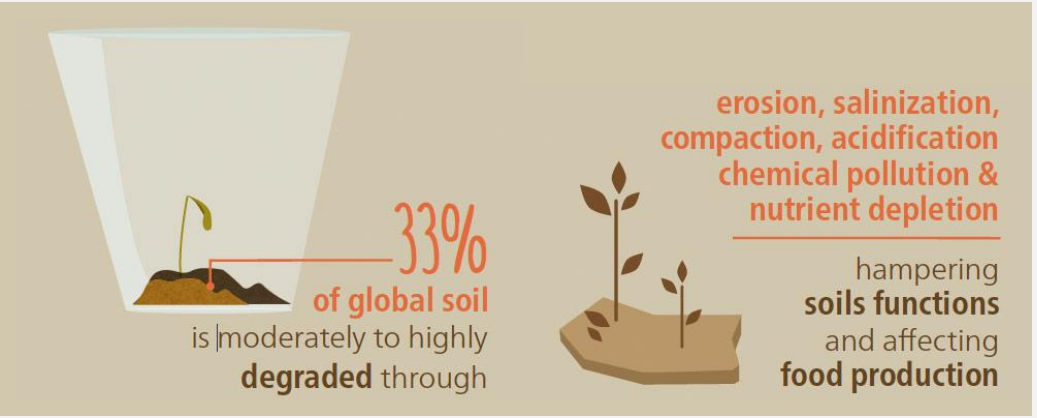
- Soil is a non renewable resource
- UK soil contains about 10 billion tonnes of carbon
- In England and Wales 4 million hectares are at risk of compaction (26% of land area)
- And 2 million hectares at risk of erosion



Status of the World's Soil Resources produced by FAO 2015

Identified 10 main soil threats globally, including waterlogging

Majority of the world's soil resources are only fair, poor or very poor condition



EFFECT OF CONFLICT ON SOIL

- Heavy metal pollution (e.g. Cu, Pb, Cd, Mo)
- Metals such as Cd and Pb can have adverse effects on human and animal health if allowed to accumulate in food chain
- Contamination from flood water – can spread pollutants over farmland, particularly in mining areas.

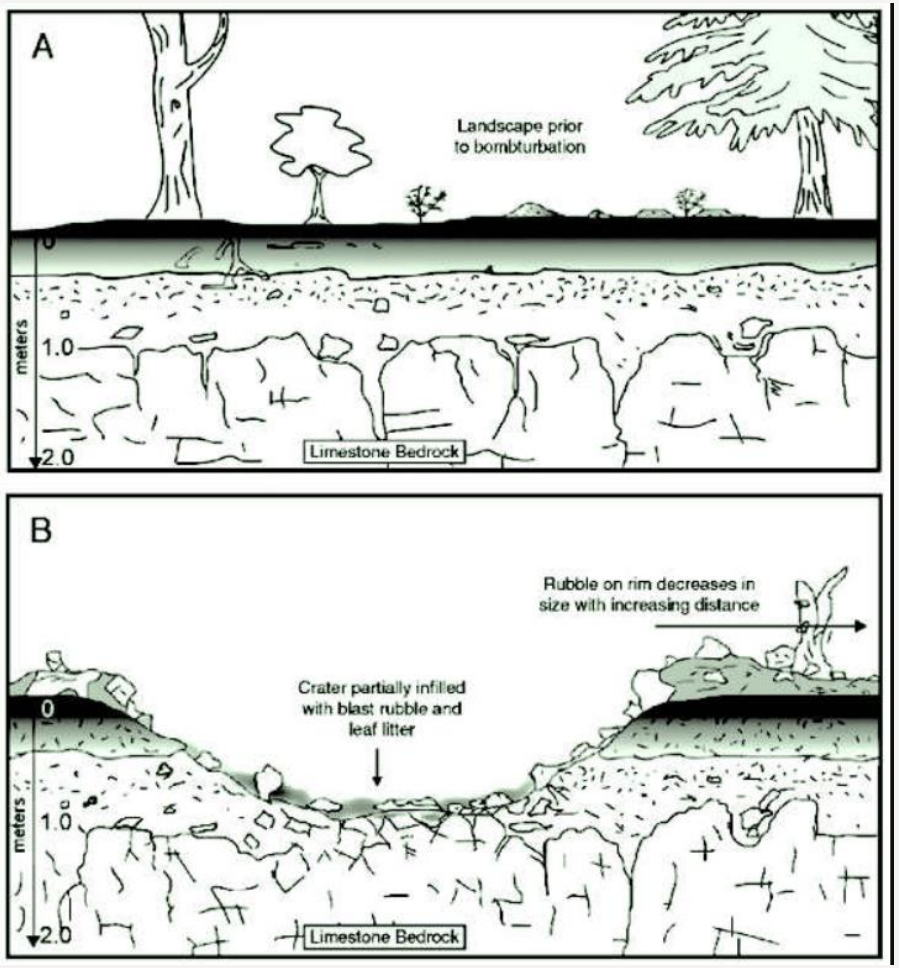
CEREDIGION CASE STUDY

- 2012 wettest summer for 100 years in Wales – leading to widespread flooding of Ceredigion area
- Concerns raised about mine contamination from floodwater
- Mines in the area (many unused for 100 years) have left toxic metals (lead, zinc and cadmium) in river banks and nearby areas – toxins could pollute land and pose risk to animals and crops (2013).
- Further research by Foulds et al., 2014 found lead concentration in flood sediment 82 times above threshold levels
- Contamination of animal feed caused lead poisoning and death in cattle

- Silage produced from flood affected fields contained up to 1900 mg/kg of lead sediments
- Climate change means events like the summer of 2012 more likely and could intensify

EFFECT OF CONFLICT ON SOIL

- Large-scale impact to soil structure
- "Bombturbation" excavates a volume of soil from the site of impact; spreading the ejecta over the surrounding area (over-burden).
- Historic studies from WWII craters have found changes in pH, organic matter composition, electrical conductivity as well as heavy metals.
- However, limit research on recent craters…

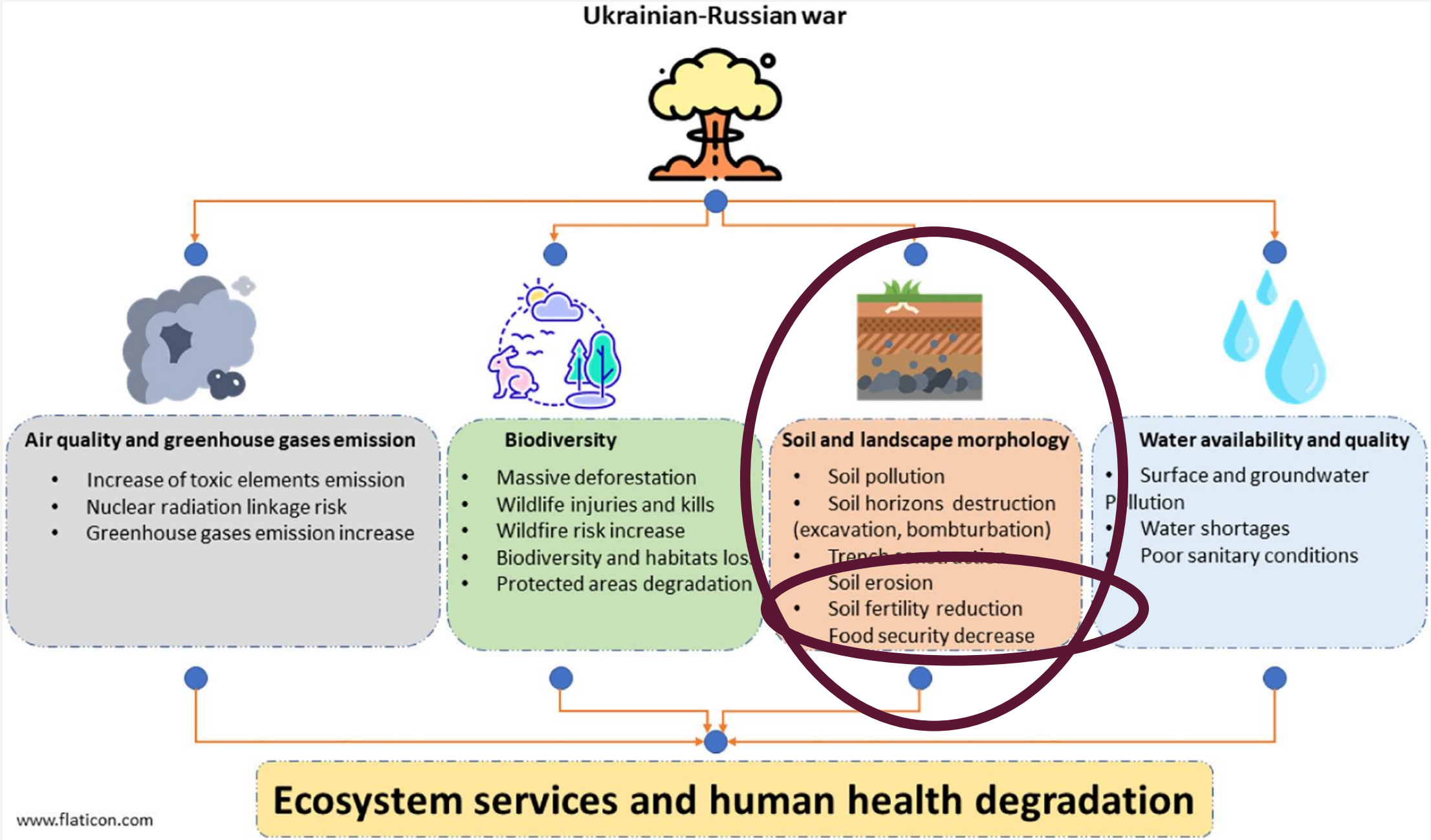


SIMILAR DEVASTATION TO A LARGE SCALE EROSION EVENT

https://www.bbc.co.uk/news/world-europe-57862894

RESTORATION ONE YEAR LATER

One litre of used motor oil can pollute up to 3784 m^2 of soil, making it non-productive for farming or plant growth for up to 100 yrs (Chin et al., 2012).

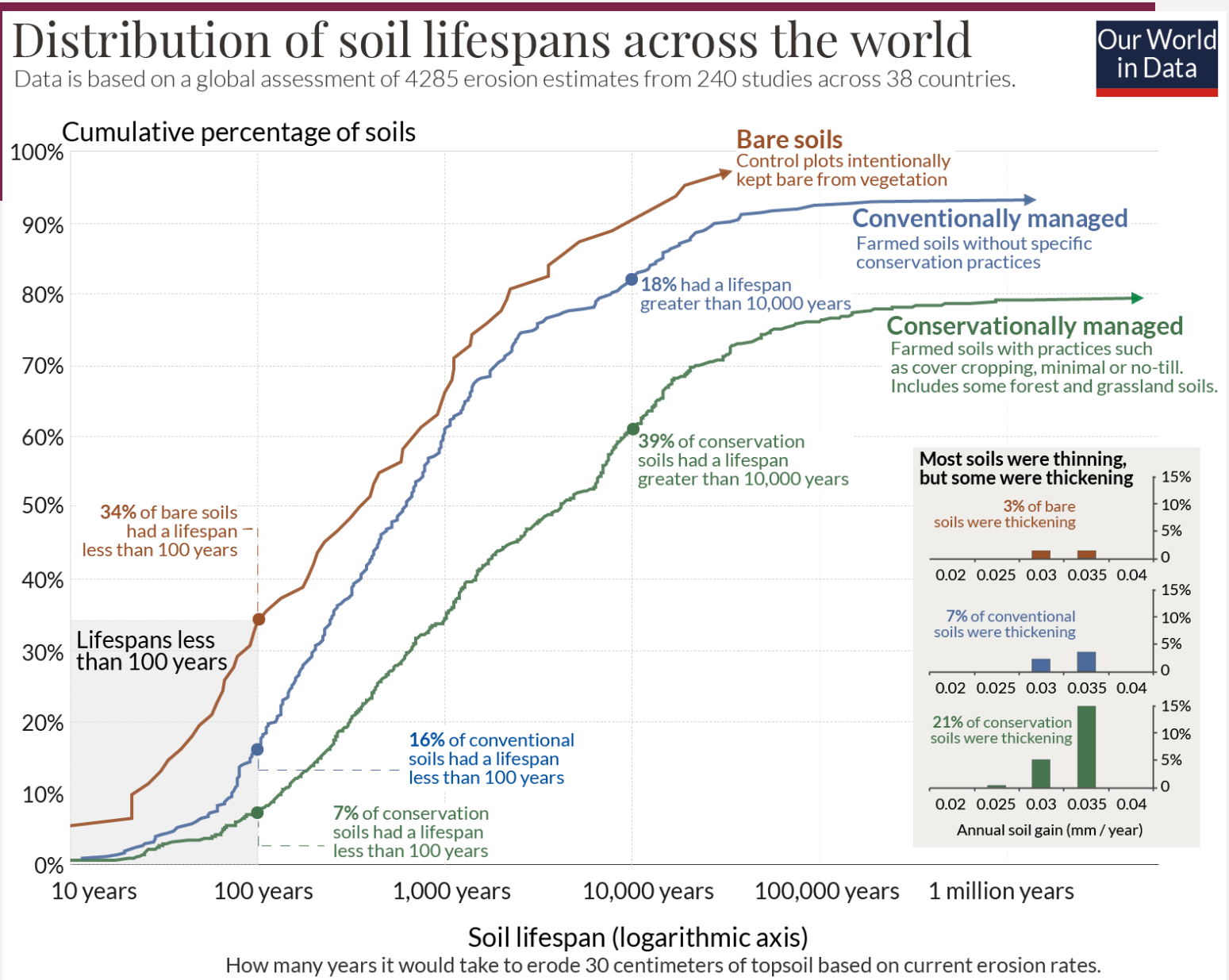

Ukrainian-Russian war
Air quality and greenhouse gases emission
• Increase of toxic elements emission
• Nuclear radiation linkage risk
• Greenhouse gases emission increase
Biodiversity
• Massive deforestation
• Wildlife injuries and kills
• Wildfire risk increase
• Biodiversity and habitats los
• Protected areas degradation
Soil and landscape morphology
• Soil pollution
• Soil horizons destruction (excavation, bombturbation)
• Soil erosion
• Soil fertility reduction
Food security decrease
Water availability and quality
• Surface and groundwater
llution
• Water shortages
• Poor sanitary conditions
Ecosystem services and human health degradation
www.flaticon.com

60 HARVESTS LEFT?

- Degraded soil
- Desertification
- Soil erosion

- 16% of soils are estimated to have a lifespan of less than 100 years
- 50% of all soils have a lifespan greater than 1000 years

https://iopscience.iop.org/article/10.1088/1748-9326/aba2fd



Source: Daniel Evans et al. (2020). Soil lifespans and how they can be extended by land use and management change.

WHAT IS SO

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Available online at http://journal.hep.com.cn/fase

Front. Agr. Sci. Eng. 2020, 7(3): 246–250
https://doi.org/10.15302/J-FASE-2020326

PERSPECTIVE

Soil health—useful terminology for communication or meaningless concept? Or both?

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Received.

Abstract:
services, su
decompositi
associated w
the main com
production syst
mycorrhizal fun
and nutrient avai
resistance to envir
tillage improve soil
Conservation tillage c
as compared to conven
high labor demands fo
which typically have les
will discuss the external fa
of crop management practi

Keywords: mycorrhizal fun
biodiversity

What is soil health? It is not essential to have a degree in soil science in order to ha
general sense, almost everybody has some impression of what is meant by a h
has done any gardening or even looked after a potted plant on a windowsill. Th
beautiful crumbly structure, should hold water but not become waterlogged,
life does not include insects or pathogens that damage the plants. In
"wellbeing" is used concerning the way individual humans feel about ther
on what contributes to our personal wellbeing. It is likely to include bein
adequately fed and being housed. However, social scientists have ta
wellbeing and even using these to compare the state of wellbeing
policies on the way people feel. Some may consider that this is
health, perhaps soil scientists make it too complicated. However, altho
makes a healthy soil, if the term is to be used in anything other than general
a little deeper", if readers will excuse the pun.

...bitat
...lands
...d in woodlands
Mesofauna as bioindicators
7 Conclusion
8 Where to look for further information
9 References

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COMMENTARY

Is 'soil health' meaningful as a scientific concept or as terminology?

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Baveye (2021) provides a robust critique of the proposal by Lehmann et al. (2020) that 'researchers should embrace soil health as an overarching principle to which to contribute knowledge, rather than as only a property to measure.' I would like to contribute to this discussion, making two points. The first is negative, reinforcing the reservations about soil health as an 'overarching principle' as set out by Baveye (2021). But the second is more positive, proposing that soil health has real value as a *means of communication* between soil scientists and non-specialists, especially politicians and policy makers.

functions, introduced by soil surveyors in the 1960s (Bibby & Mackney, 1969; Klingebiel & Montgomery, 1961), is more helpful.

Effective communication between soil scientists and non-specialists is extremely important, especially because there is evidence that many soils globally are suffering from degradation or pollution caused by a range of human activities (FAO & ITPS, 2015; Lal, 2020). My observation is that the *term* 'soil health' achieves resonance with those who are not specialists in the study of soil, especially politicians and policy makers. As an example, the UK Government's

Received June 29, 2012
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Soil Use and Management — WILEY

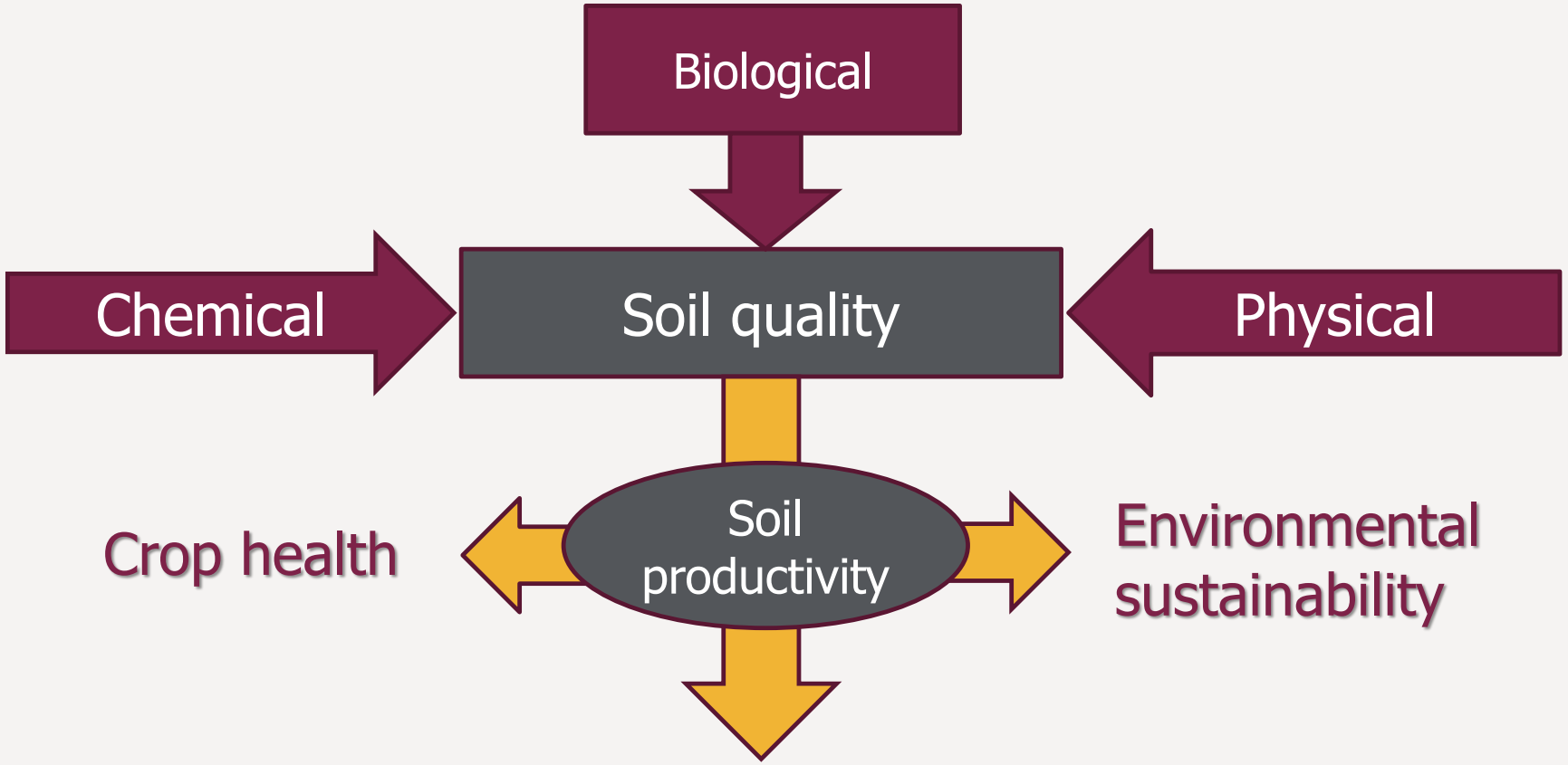
...gricola

...d to assess the

...ii Horta Miyauchi[1],
...yoshi Nakatani[1], Jamil

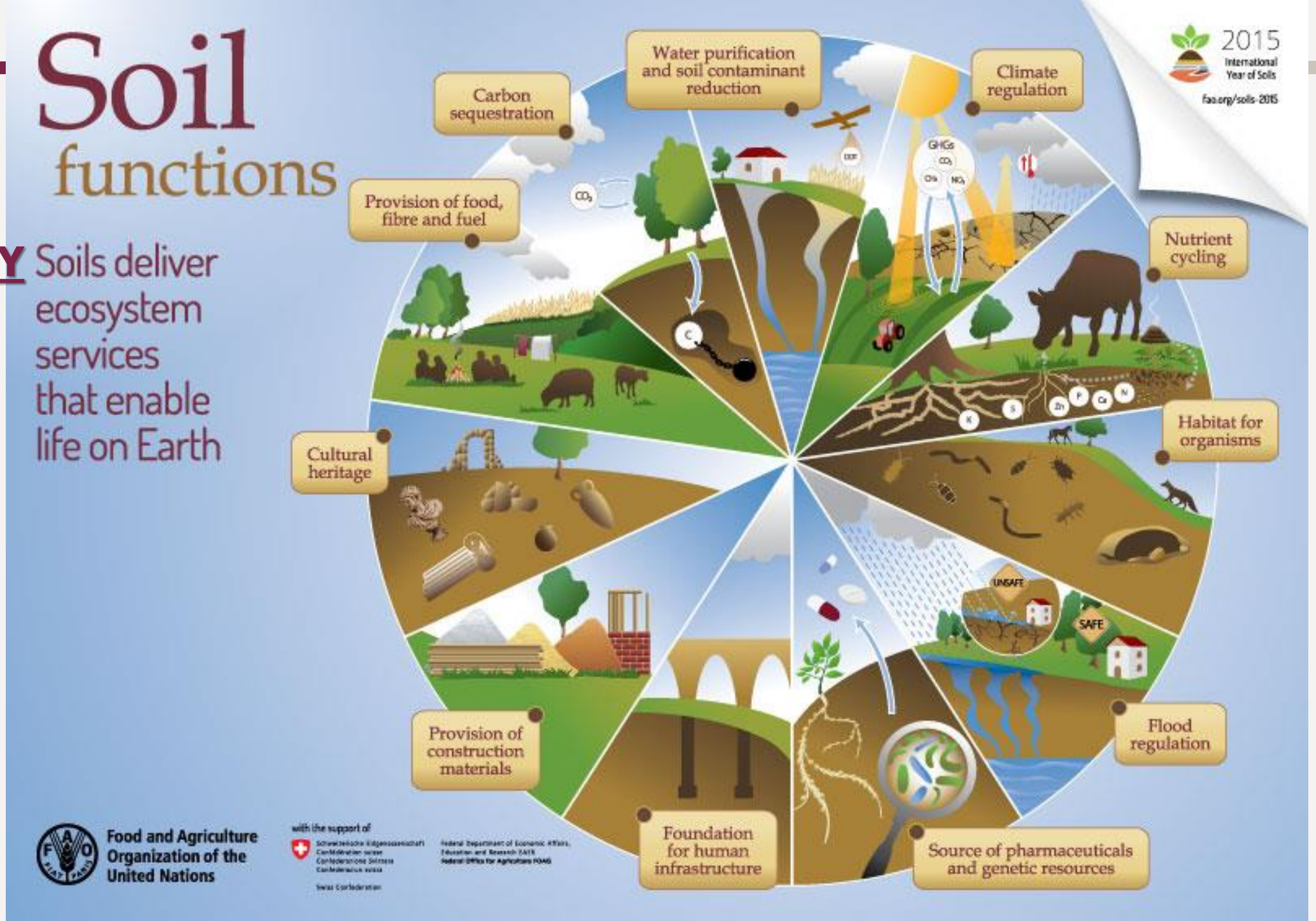
...n and the functionality of a soil and its
... biodiversity above and below surface,
...ool for sustainability, physical, chemical,
...iich respond to the soil use and manage-
...id response to natural or anthropogenic
...among the physical indicators, soil texture,
...e been used, while among chemical indica-
...r, cation exchange capacity, among others
...lly have a slow response, when compared to
...nd N, biodiversity, soil enzymes, soil respira-
...hus, a systemic approach based on different
...cal) in assessing soil health would be safer than
...tivities have caused desertification, loss of bio-
...anic matter and nutrients, among others. Today,
...ctivity with increasing emphasis on reforestation
...the use of organic amendments, reintroduction of
...eview focused on an integrative view on indicators
...on of sustainability in production systems.
...oil fauna, soil quality, sustainability

WHAT MAKES A "HEALTHY" SOIL IN AGRICULTURE?



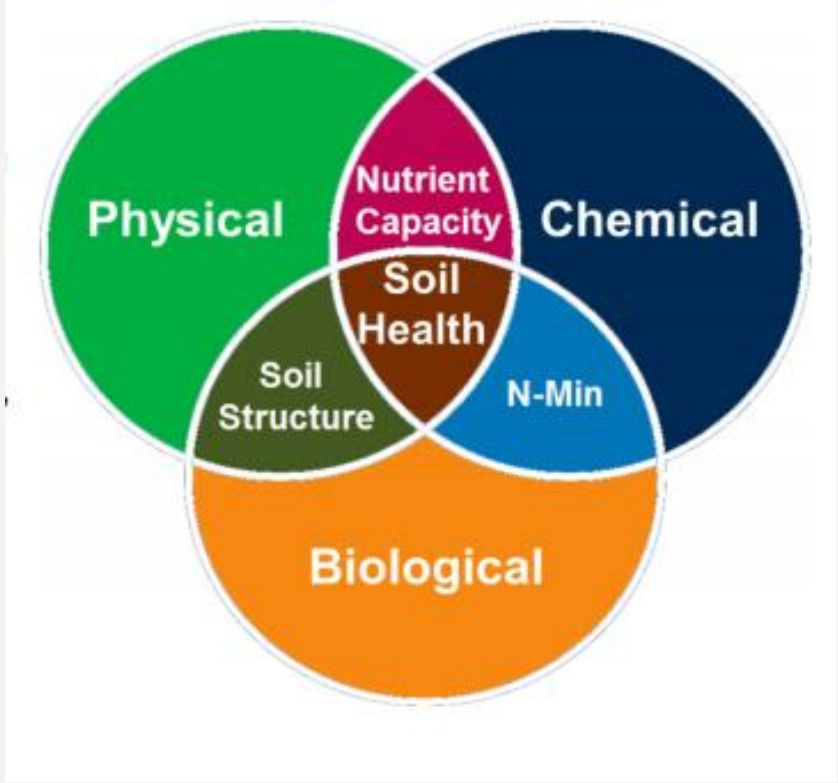
SOIL HEALTH

HEALTHY


Soil functions
Soils deliver ecosystem services that enable life on Earth
2015 International Year of Soils
fao.org/soils-2015
Carbon sequestration
Water purification and soil contaminant reduction
Climate regulation
Provision of food, fibre and fuel
Nutrient cycling
Cultural heritage
Habitat for organisms
Provision of construction materials
Flood regulation
Foundation for human infrastructure
Source of pharmaceuticals and genetic resources
UNSAFE
SAFE
GHGs
Food and Agriculture Organization of the United Nations
with the support of

WHAT IS SOIL HEALTH?

- Soil health refers to "the continued capacity of a soil to function" (Doran and Zeiss, 2000).
- BUT// Only something living can have health, thereby we are (unconsciously) acknowledging that we regard soil as a living ecosystem and not just an inert base for agriculture.



SOIL: THE POOR MAN'S TROPICAL RAINFOREST

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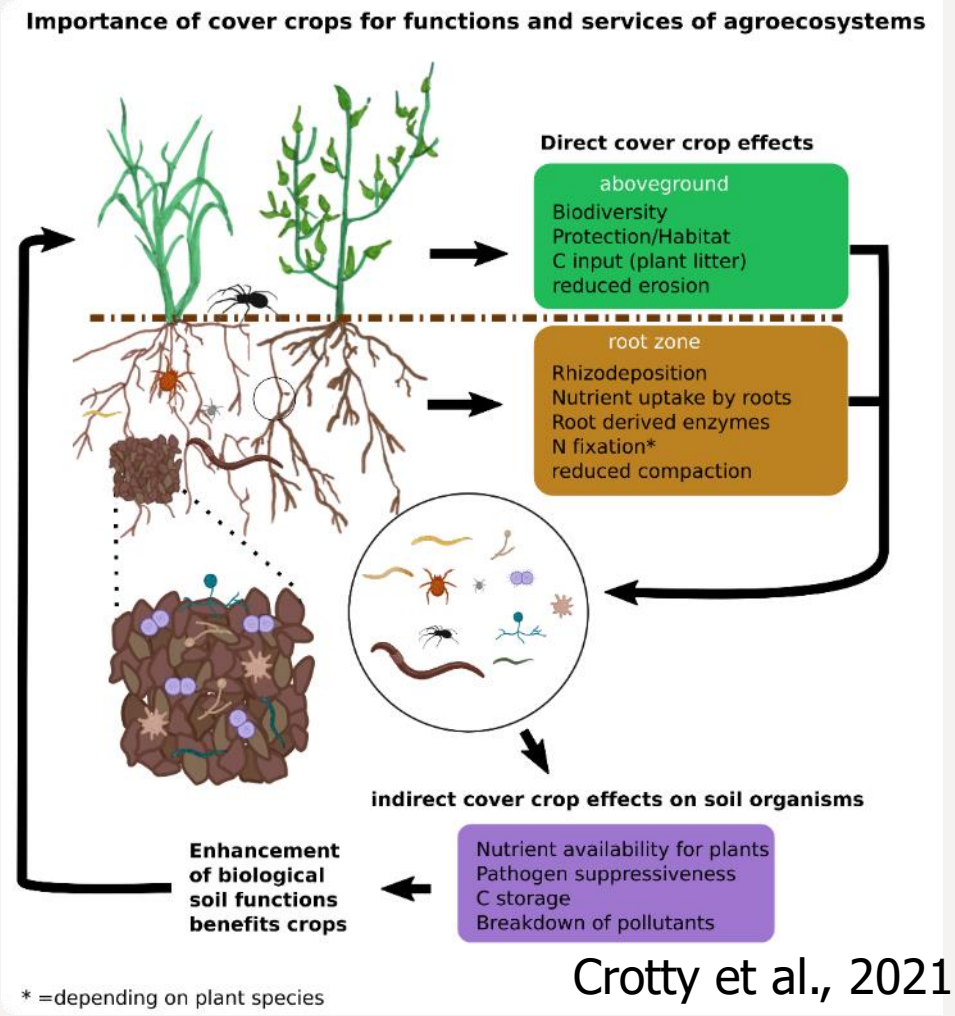
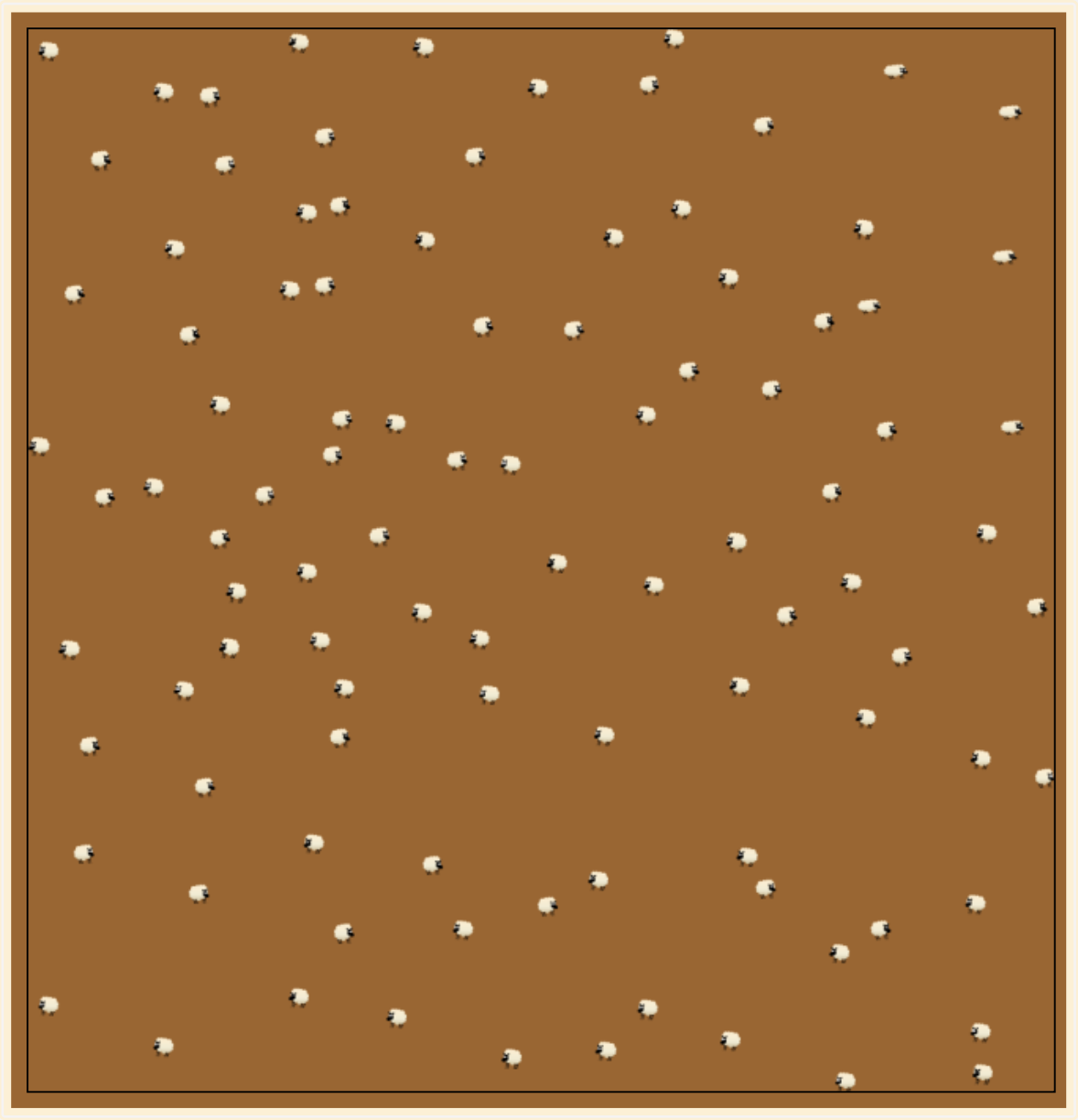
- Soil organisms are driving soil functions
- Agricultural practices can change the soil habitat influencing the abundance and diversity of soil fauna.
- But even arable soil has large abundance of soil fauna….



Crotty et al., 2021

One hectare of arable soil has the equivalent to THREE TONNES of soil fauna

Or 53 sheep



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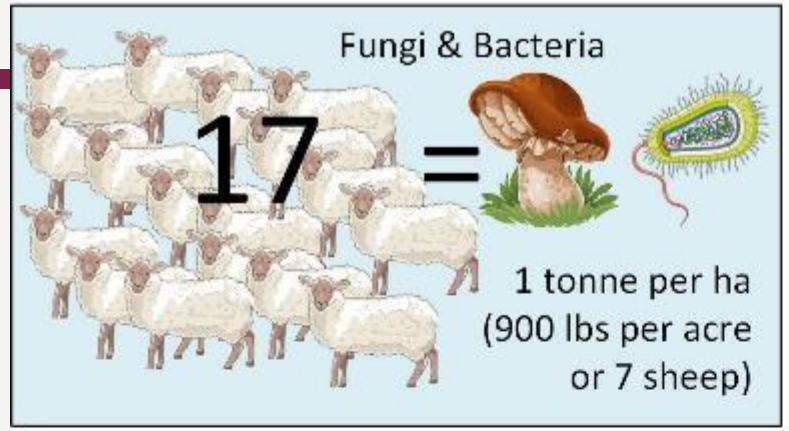

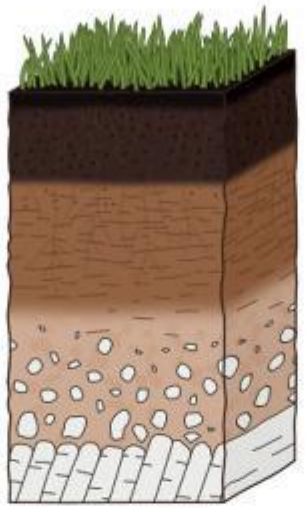

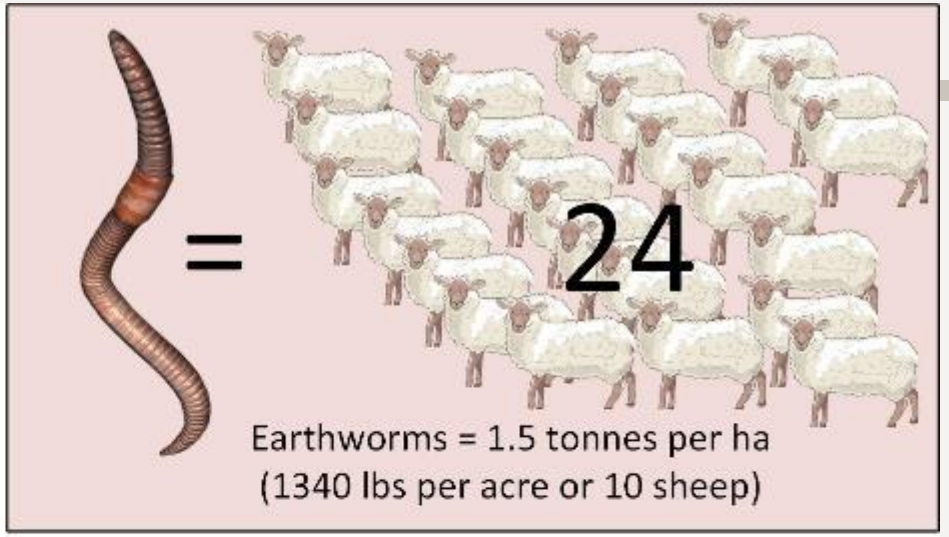

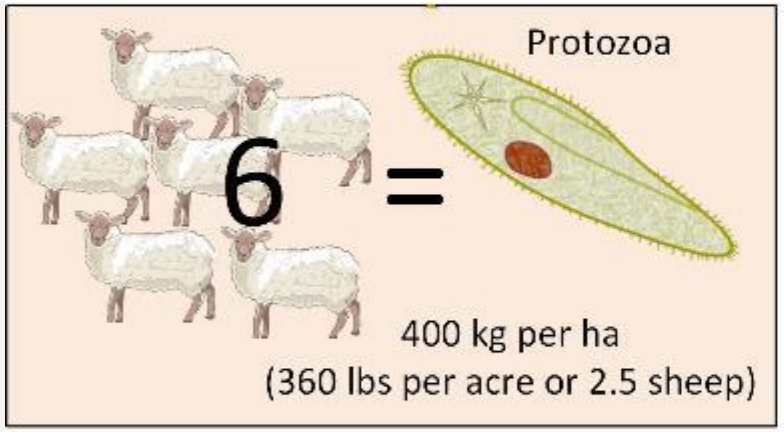

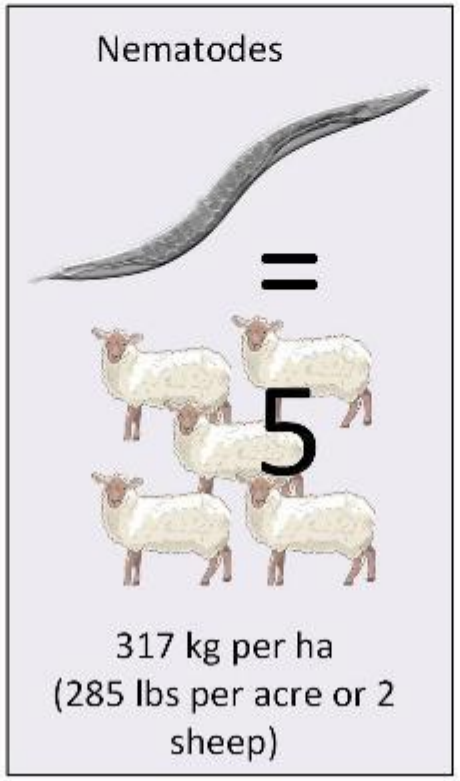

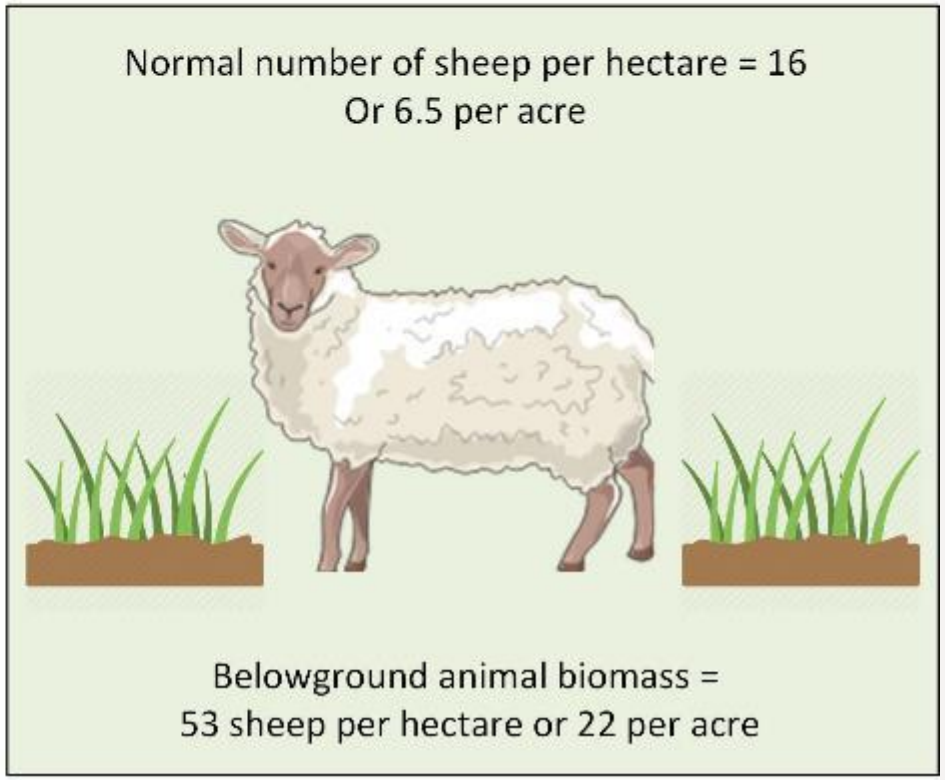

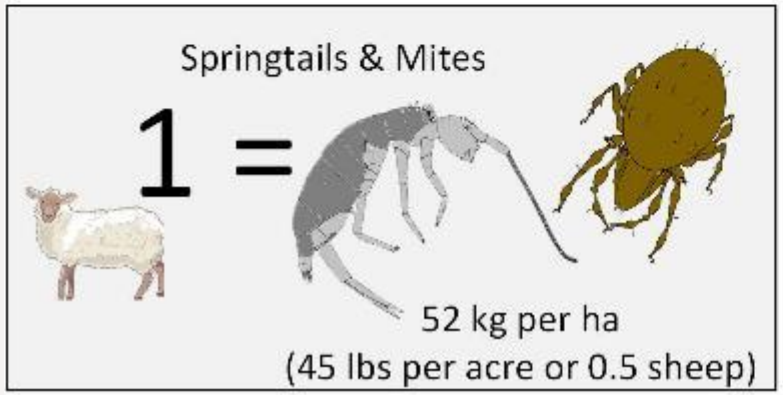

Crotty (2022) https://kids.frontiersin.org/articles/10.3389/frym.2022.660785

EARTHWORMS AS ECOSYSTEM ENGINEERS

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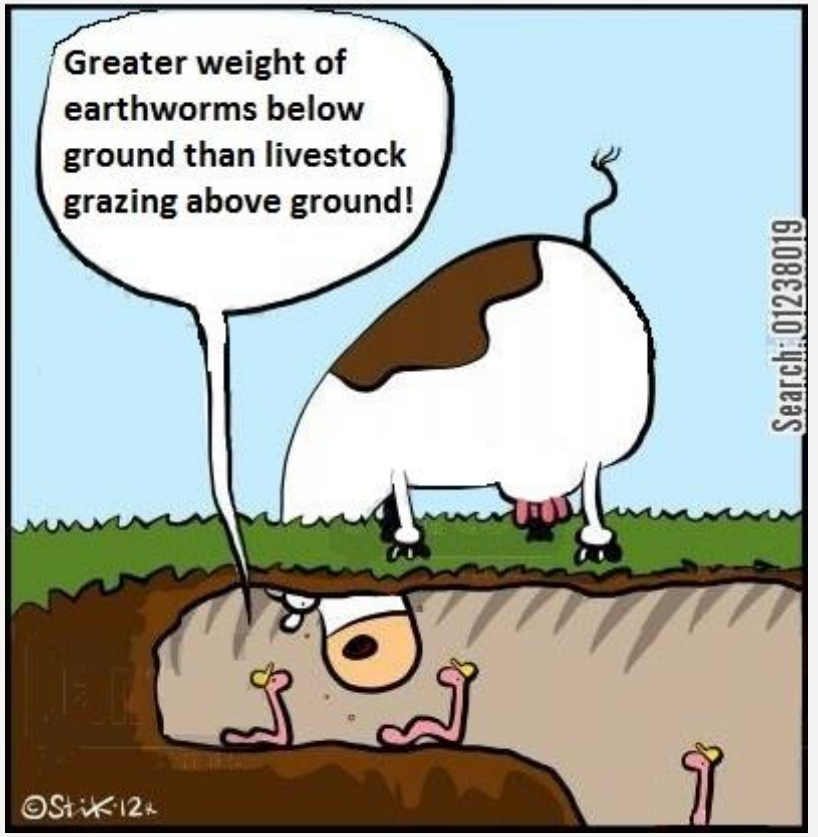
- Found to increase CROP YIELDS up to 25%!
- Knowing how many earthworms you have is a quick and easy gauge of soil health
- More than 16 per spade-full = 400 per m^2 (approx)

  = bench mark for a healthy soil?



Up to 3 tonnes per ha

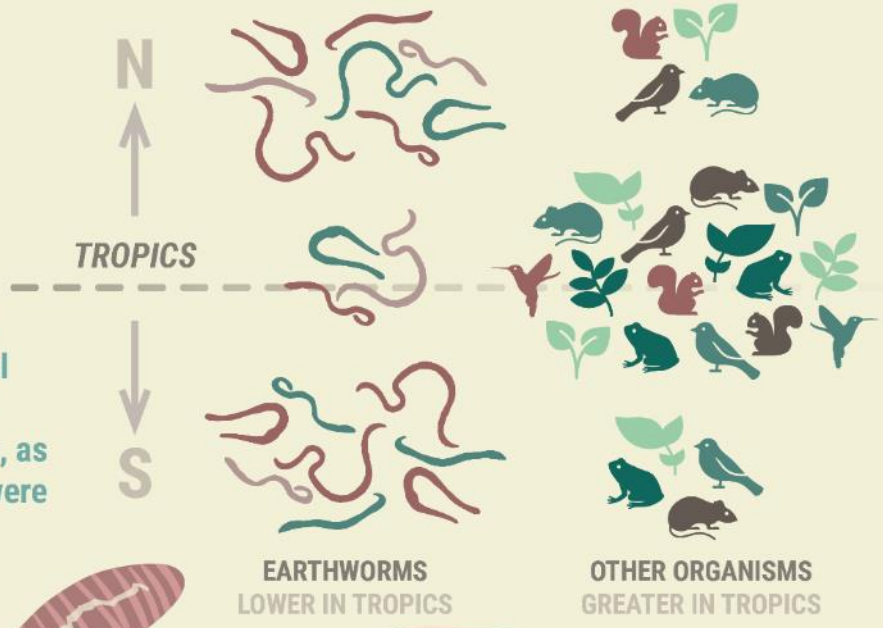
SOIL INVERTEBRATES PERFORM KEY ECOSYSTEM SERVICES. BUT DESPITE THEIR IMPORTANCE, NOT MUCH IS KNOWN ABOUT THEM AT THE GLOBAL SCALE.

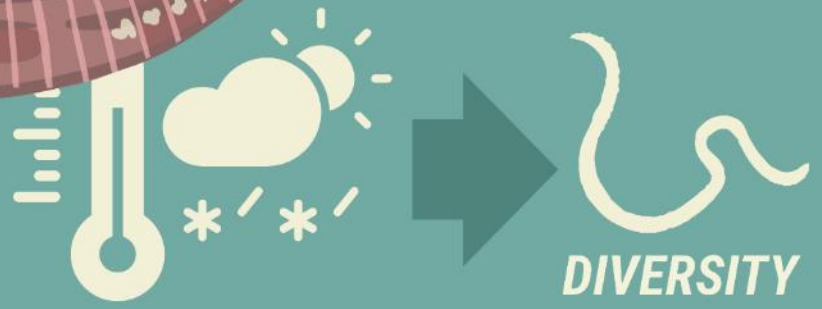
WE COMPARED THE DISTRIBUTIONS OF EARTHWORM SPECIES ACROSS THE GLOBE TO FIND OUT THEIR GEOGRAPHICAL PATTERNS AND MAIN DRIVERS.

BIODIVERSITY

Surprisingly, patterns of local earthworm diversity were opposite to those of aboveground organisms.

However, we suspect that across the tropics the total number of earthworms is greater than other regions, as earthworm communities were highly dissimilar from each other.





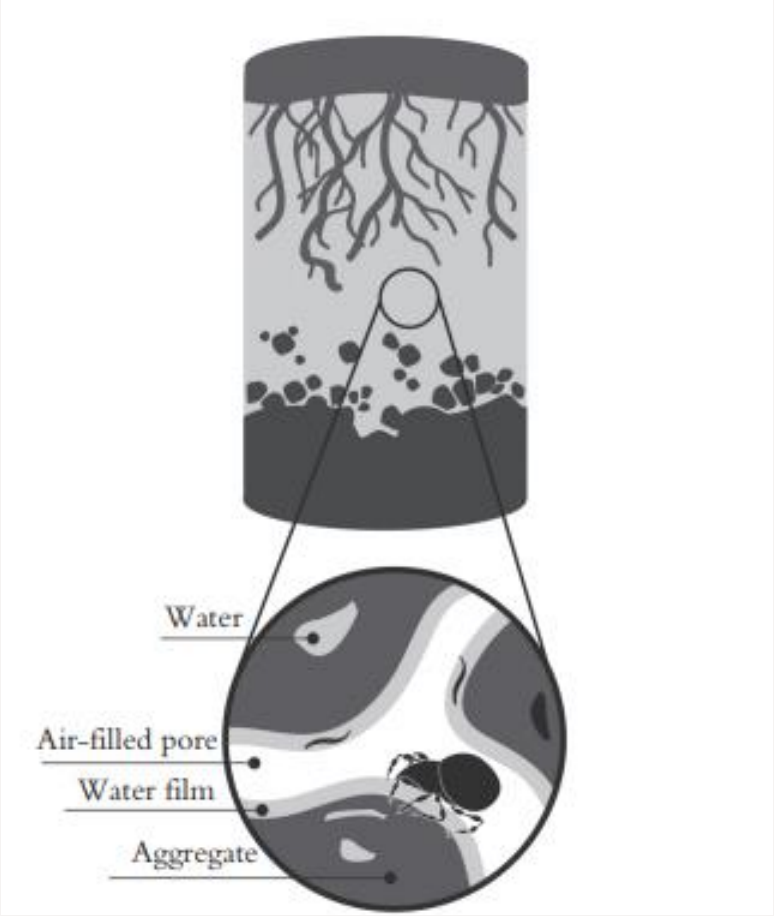
The biggest drivers of earthworm biodiversity were variables related to climate, meaning climate change could have serious effects on soil communities and the ecosystem services they provide.

TO LEARN MORE, CONTACT:
SWORM@IDIV.DE

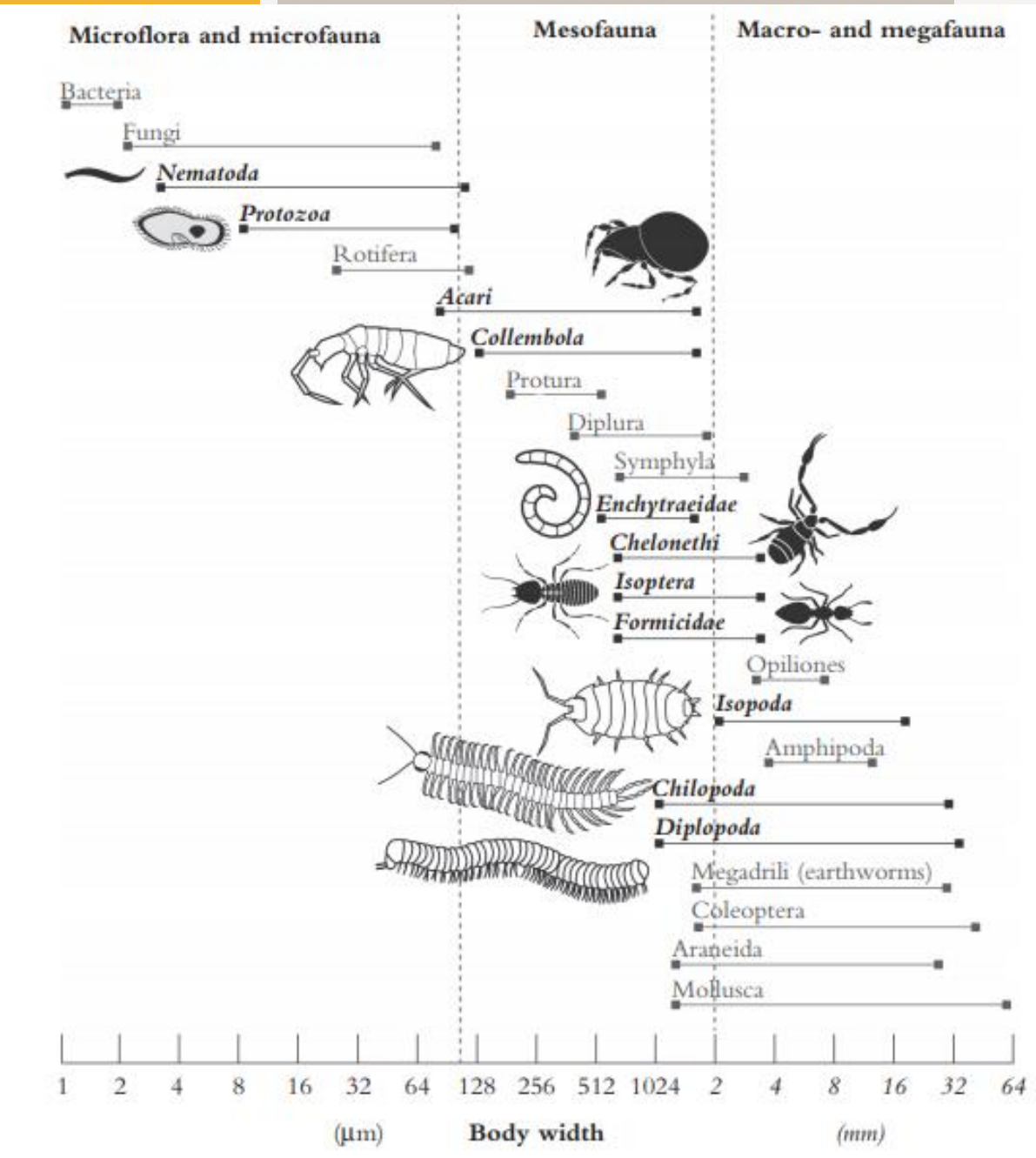
INFOGRAPHIC BY KATE BROADLEY OF FUSE CONSULTING LTD.

SOIL PORES – 3D SPACE

- Soil environment shows extreme variation in space (and time)
- Wide range of surface types, pore size, microclimate and resources for organisms to live in/on and utilise
- E.G. Roots use pores of >100 µm as points of entry, while root hairs, protists, fungi use pores of > 10 µm, whilst bacteria can move in water films of only 1 µm depth



WHAT ARE MESOFAUNA?



BUT WHAT ARE MESOFAUNA?

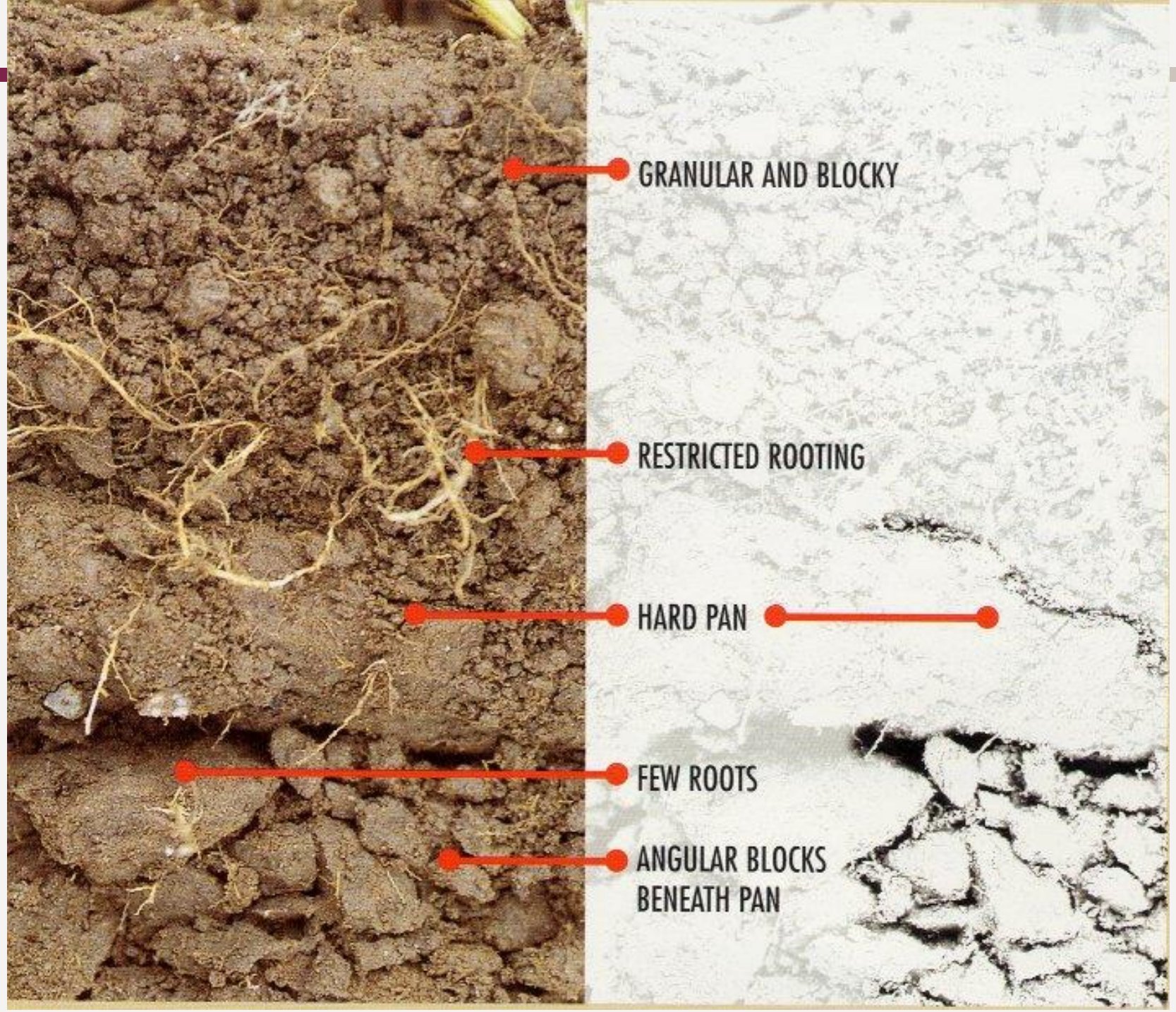
https://www.chaosofdelight.org/collembola-springta

BUT WHAT ARE MESOFAUNA?

https://www.chaosofdelight.org/collembola-springtails

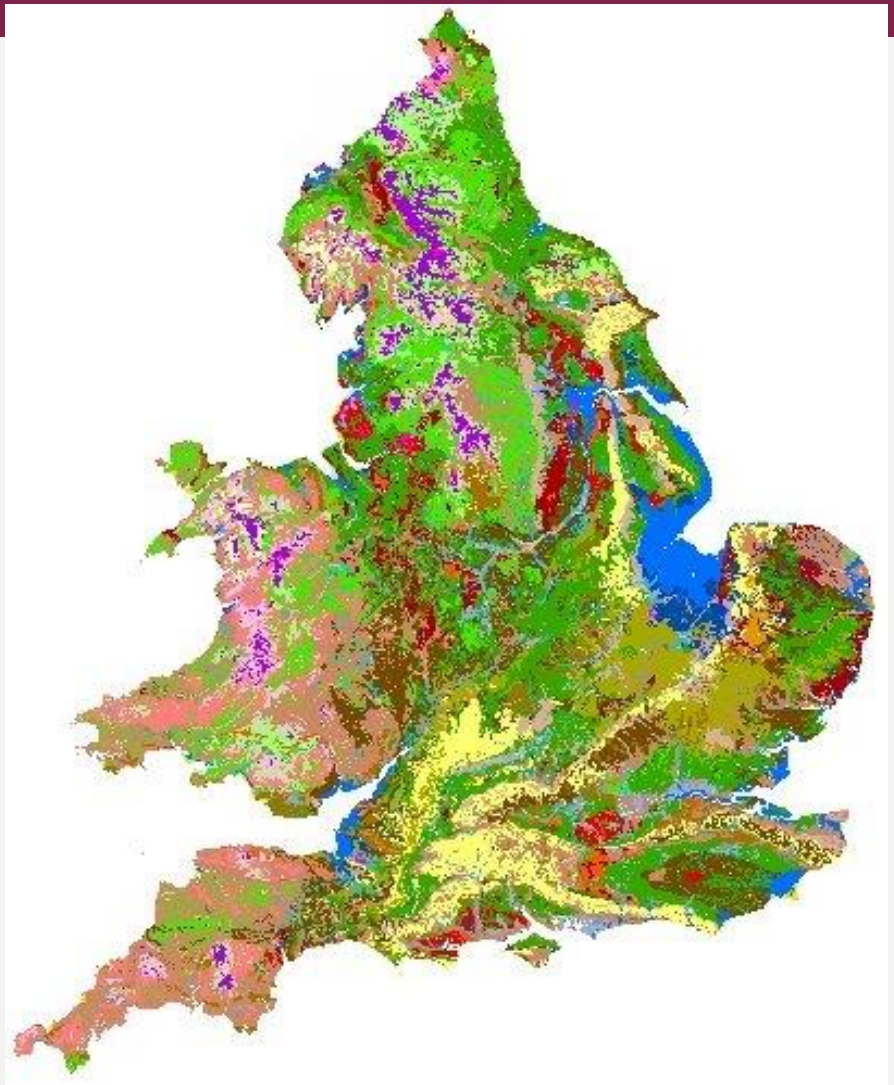
BUT WHAT ARE MESOFAUNA?

https://www.chaosofdelight.org/mites



- A – Topsoil
- B – Subsoil

HOW MANY DIFFERENT SOILS ARE THERE?

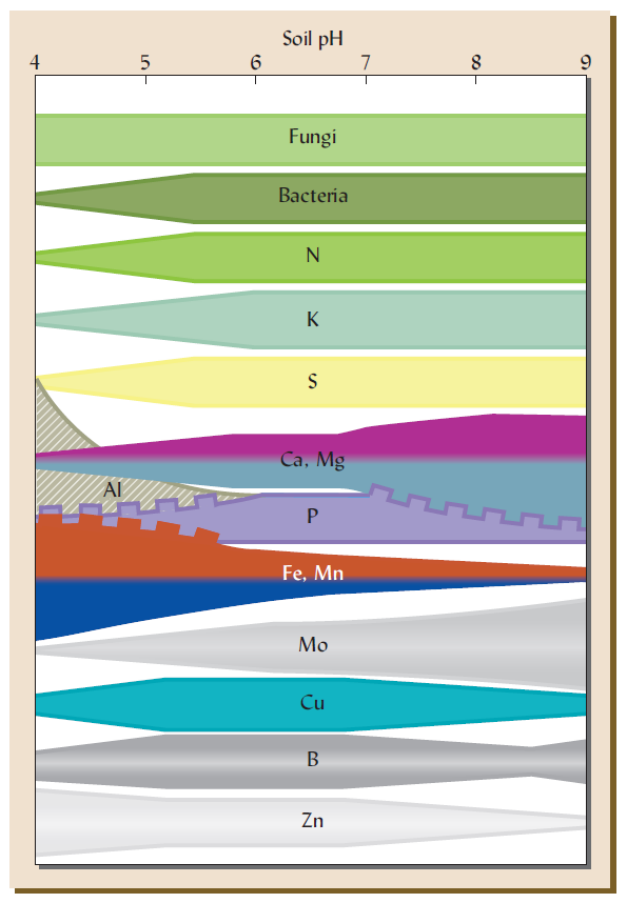


- http://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/regional-and-national-soil-maps-and-databases/en/
- 683 soil series in England and Wales
- ~400 in Scotland

DIFFERENCES BETWEEN REMEDIATION AND RESTORATION

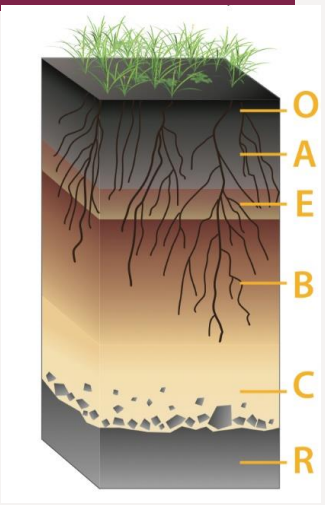
REMEDIATION

- Return soil to area
- Reduce / remove contaminants
- Consider pH
- Add plant cover



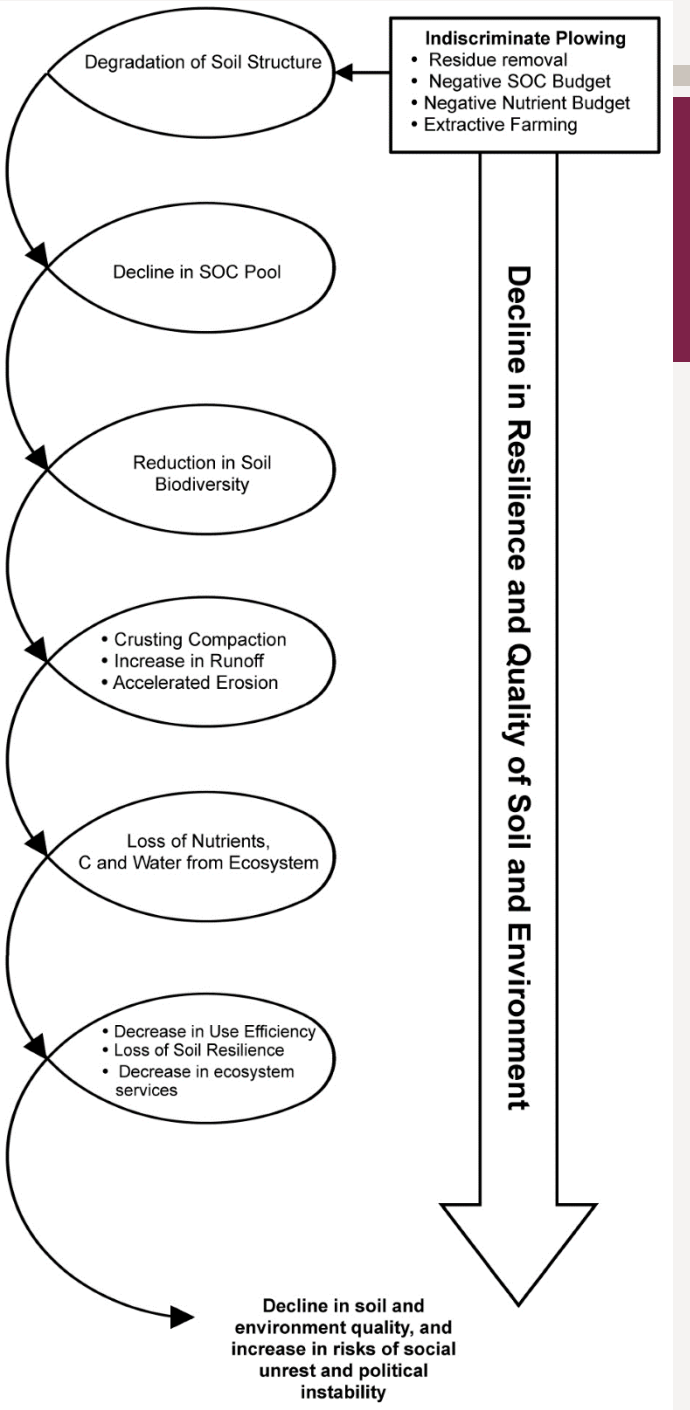
RESTORATION

- Restore function
- Consider soil horizons
- What about soil structure?
- What about organic matter
- What about soil biodiversity



SOIL DEGRADATION

- Fertile soils require **significant** time to develop through the process of soil formation.
- Very easy (and quick) to lose / damage soil
- Human activities often reduce soil fertility and increase soil erosion.
- Soil conservation strategies exist and may be used to preserve soil fertility and reduce soil erosion.



THANK YOU – QUESTIONS?

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