Bringing Science to Society through Co-Innovation and Co-Creation – The Soil-Health and Food Mission

EURAGRI conference, 27-28th September 2021

Évora (Portugal)

- *Monitoring and the question of relevant and meaningful indicators*

- *Bridget Emmett*
- *UK Centre for Ecology and Hydrology &*

Member of the EU Mission Board for Soil Health and Food

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This talk will cover....

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- What do we need soil indicators for? What are our target outcomes?
- Questions:
  1. Can we use management activities as proxy indicators?
  2. Aren't soils too variable, slow to respond and expensive to monitor?
  3. Can't we use water quality, above-ground biodiversity and air quality to tell us about soil health?
  4. Is there a more efficient and resilient way to measure soil recognising they are part of an ecosystem?
  5. Can remote sensing remove the need for classic, in-field assessment?
- Next steps for developing monitoring proposed by the mission.

What is healthy soil?

The EU mission for Soil Health and Food defines this as:

”the continued capacity of soils to support ecosystem services”

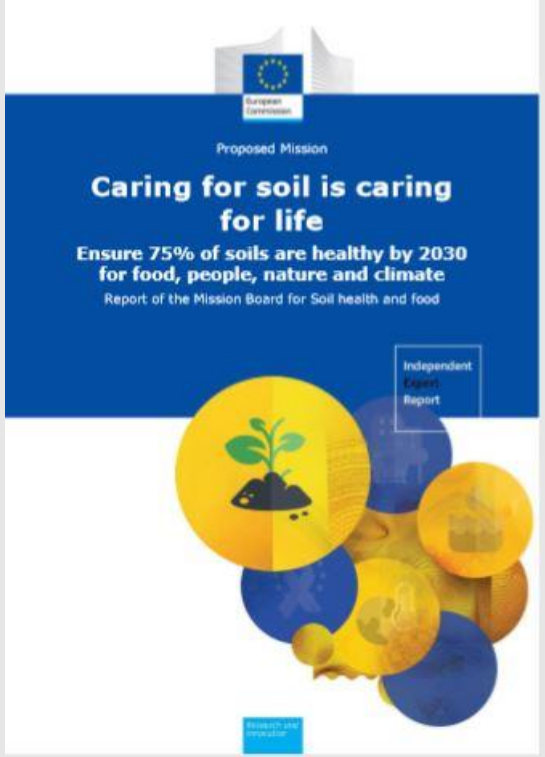
This definition recognizes soils deliver a range of **vital, interconnected ecosystem functions** related to water regulation, biodiversity, nutrient cycling, climate mitigation and adaptation, landscape features and cultural services.

https://op.europa.eu/en/publication-detail/-/publication/4ebd2586-fc85-11ea-b44f-01aa75ed71a1/language-en/format-PDF/source-159637857

But the EU Mission Board in 2020 with JRC reviewed a wide range of available evidence and concluded…

60-70% of EU soils are unhealthy impacting food, people, nature and our climate

So our policies to protect water, air and biodiversity have NOT protected our soils. We need to explicitly target their monitoring and assessment.



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Why should we care about unhealthy soil?

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Risks from contamination

2.8 million potentially **contaminated sites**, but only 24% are inventoried and 65,500 remediated

Safe food

83% of EU soils with **residual pesticides**; 21% of agricultural soils with cadmium concentrations above the limit for drinking water; and 6% with heavy metal content potentially unsafe for food production;

Supporting biodiversity

65-75% of agricultural soils with nutrient inputs at levels risking **eutrophication of soils and water** and affecting biodiversity; + pesticides, compaction…..

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Continued biological production

24% of land with **unsustainable water erosion rates**;
25% of land at high or very high risk of **desertification** in Southern, Central and Eastern Europe

Sustainable living

Soil is the **largest source of waste** (520 million tonnes) in the EU despite the majority not being contaminated

Climate regulation

Cropland soils **losing carbon** at a rate of 0.5% per year and 50% of peatlands drained and losing carbon

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Policy success requires specific, measurable and time-bound targets which can be tracked effectively

The mission proposes specific targets as part of a new 'Soil Deal' for Europe to lead the transition toward healthy soil by 2030

1. **Halt desertification** and start restoration
2. **Reverse soil carbon** losses to an increase of 0.1 to 0.4% pa on cultivated land and increase the natural sink of peatlands
3. **Stop soil sealing** and increase re-use of urban soils
4. **Reduce soil pollution and enhance restoration** (-50% pesticides; -50% nutrients; -20% fertilizer; -30% microplastics; achieve 25% organic)
5. **Prevent and stop erosion** to sustainable levels;
6. **Reduce compaction of soils;**
7. **Reduce the global footprint of EU**'s food and timber imports on land degradation
8. Improve **soil literacy** in all Members States

… to be achieved via **actions across all types of land use, sectors** and **value chains as drivers of soil health**

And the mission proposes a specific suite of eight indicators mapped to these risks and targets

Soil structure

Soil organic carbon

Excess nutrients and salt

Soil biodiversity

Contaminants

Vegetation cover and landscape

Soil literacy

Global footprint

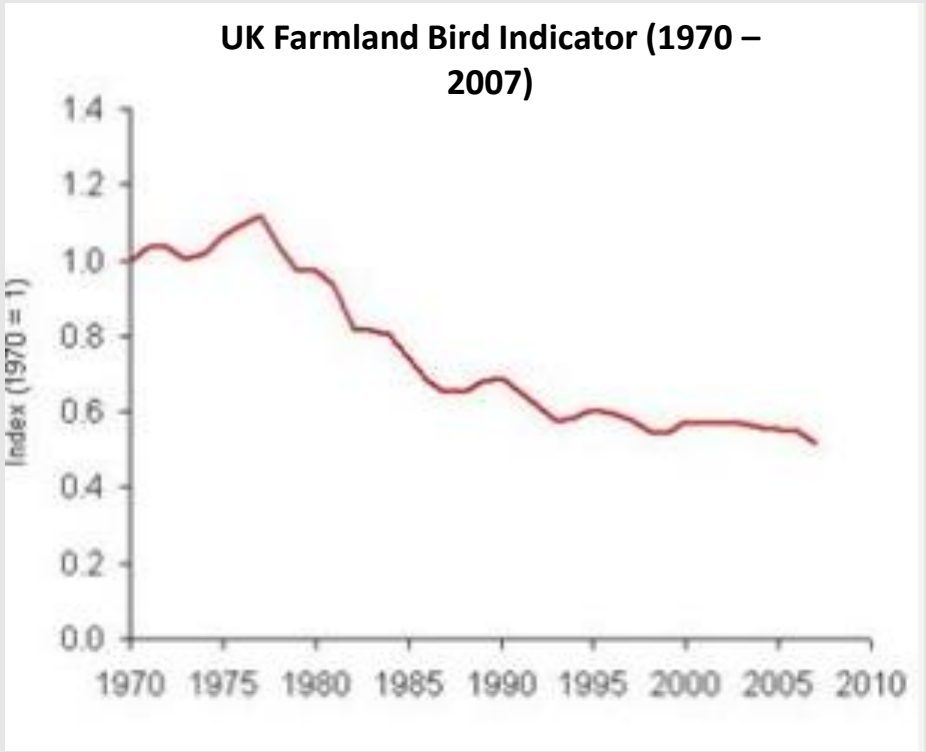
Question 1: But can't we use management activity as a proxy indicator for healthy soil?

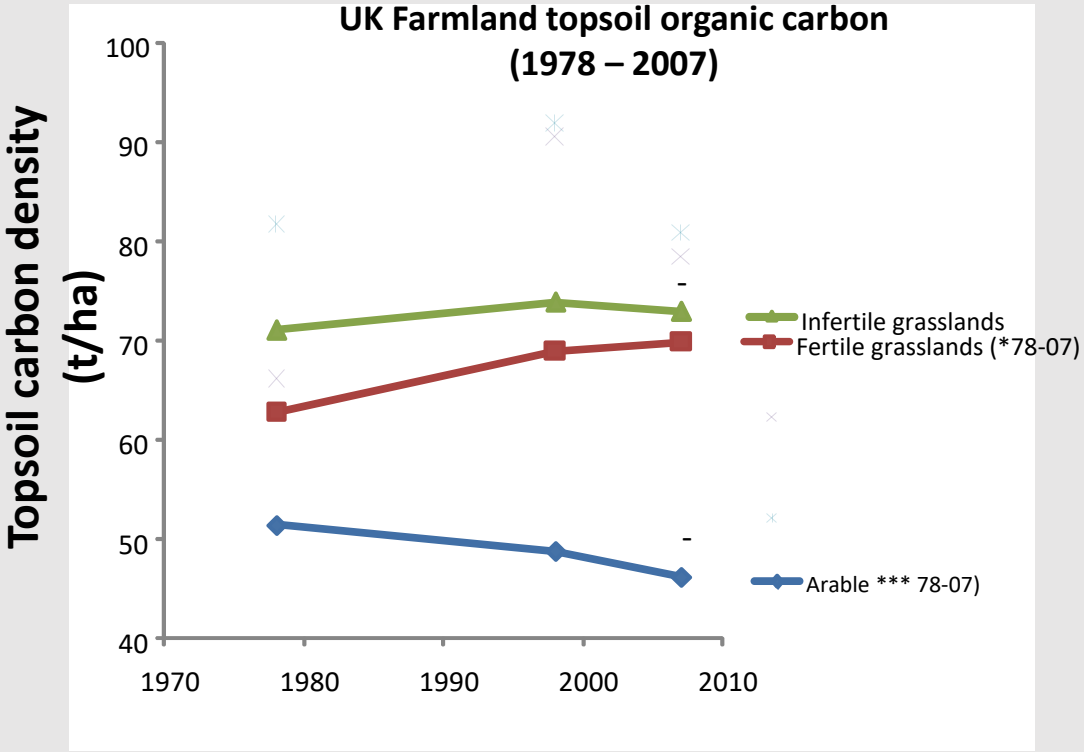
- The mission proposes this is useful only as an interim measure (< 5 years) whilst soil monitoring is enhanced.

Why?

- Uncertainty about how well management is delivered e.g.:
  - Successful cover cropping to reduce erosion relies on appropriate timing
  - Practice of no-till can result in increased soil compaction
  - Persistent use of chemicals within organic systems can result in build-up of chemicals e.g. copper in the soil
- In addition, climate change and new technologies may result in unexpected outcomes

Question 2: Aren't soils too variable, too slow to show change and expensive to monitor?





So no! Soils are no harder or more expensive to monitor than other natural resources

- Biodiversity is ‘diverse’ and yet we don’t say we can’t measure it and we have international targets and requirements to monitor it.
  - Birds – are mobile, some migrate and many factors influence their numbers;
  - Pollinators – are only possible to count when the sun shines;
  - Plants – highly variable in space, are seasonal, are subject to disease and grazing animals eat them;
- Waters
  - Rivers have floods and droughts and have constantly changing chemistry
  - There is stratification in many water bodies (just as in many soils)
  - And marine system have tides
- Air quality
  - Is hugely dynamic in both space and time and has transboundary flows

Soils are very well behaved – they don’t migrate, are relatively constant over time, do not flow across borders and are no more variable in space than our other natural resources – we just don’t fund it.

Question 3 – doesn't monitoring of water, biodiversity or air tell us if there is a problem with soil health?

- No!
  - Water quality
    - By the time nutrients or contaminants have started to leach out into the water the soil is saturated and will take years to recover. It is too late!
  - Air
    - It is more expensive than soil sampling to assess methane and N_2O emissions from soil - cheaper to measure the drivers such as water table, compaction and nitrogen levels which essentially drive the risk.
  - Above-ground biodiversity?
    - What is this – its a complex mix of plants, invertebrates, birds etc
    - And this is true also in the soil – there are many different taxa.
    - How are they linked?
      - Soil animals seem to be linked to vegetation and management intensity – but soil microbes are more driven by geology and soils (see *George et al. 2019 Nature Communications*).
      - There is no such thing as soil 'biodiversity' – it is as complex as above-ground biodiversity and we there is no agreement as to what is 'good' at present.

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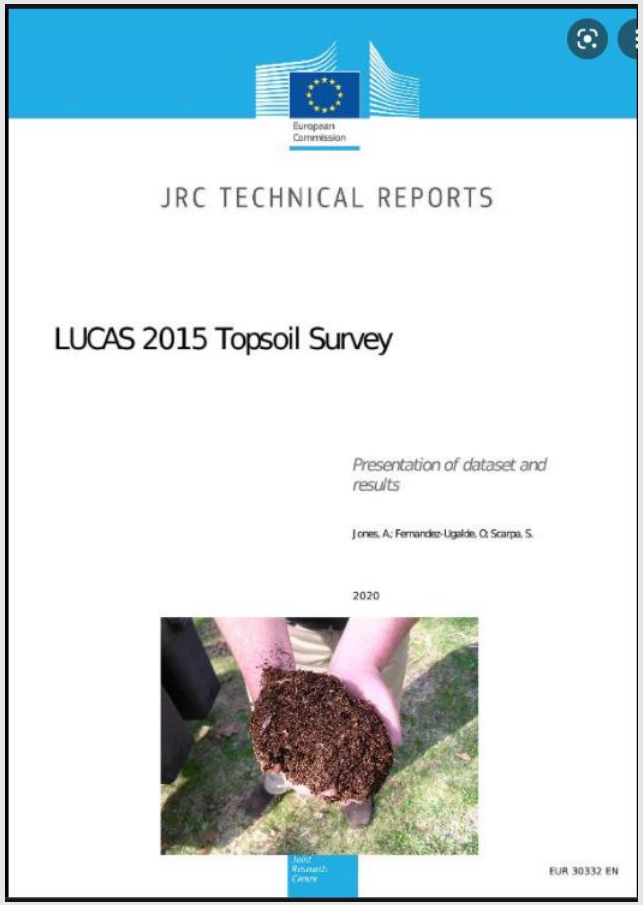
Question 4: Is there a way to make soil monitoring even more efficient and resilient to changing political and scientific priorities?

Pan-EU soil monitoring and data initiatives are already in place and the hope is for more national programmes to enhance these..

LUCAS: 2009 – 2018 (0-20cm)



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But should we move to a systems-based monitoring approach? Would these be efficient and resilient to changing political priorities and recognises soils are part of an ecosystem

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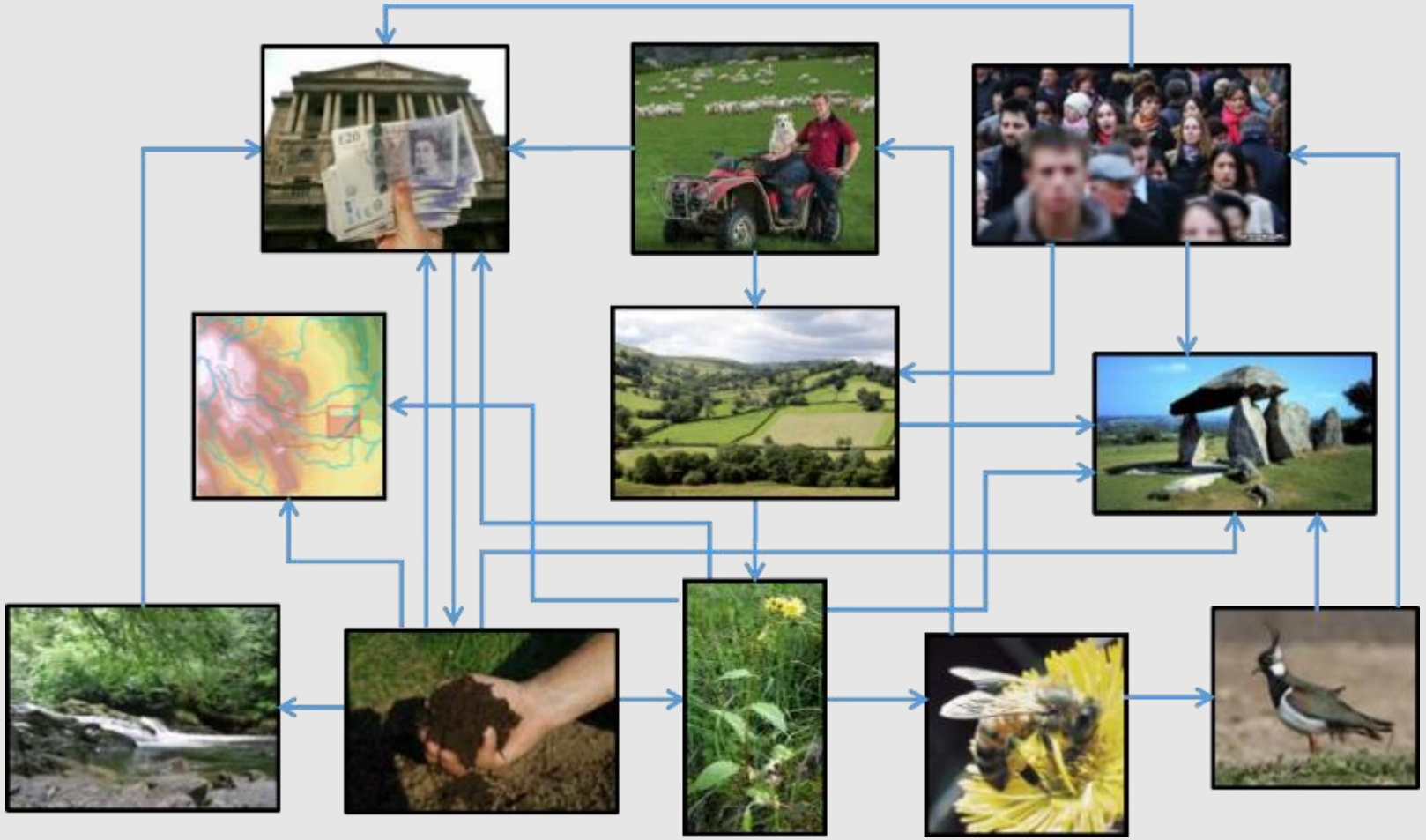


ERAMMP: A systems-based, national monitoring programme in Wales (UK) for CAP reporting and much more…..

The following is recorded by field surveyors in 300 one km squares using many methods developed for Countryside Survey:

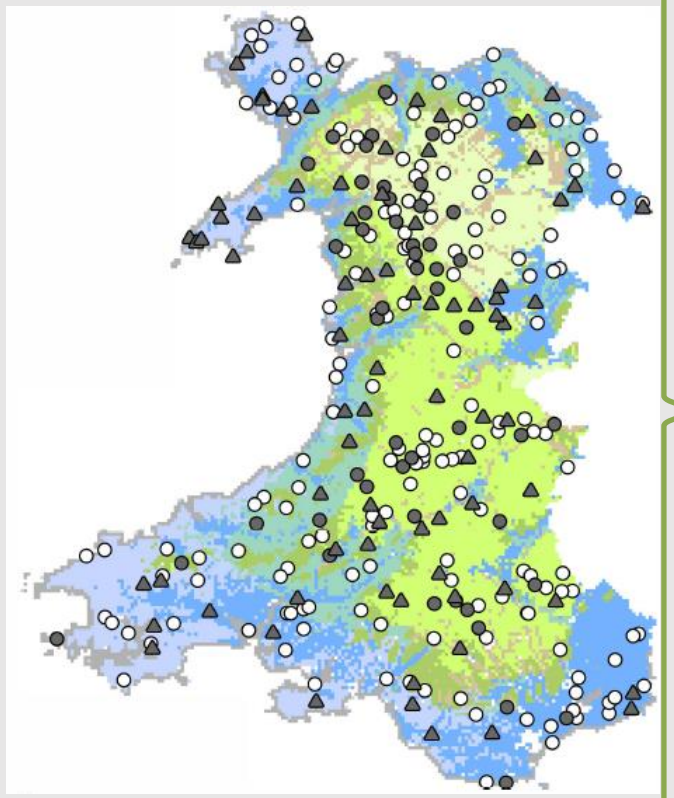
- Soil health (topsoil)
- Peat depth
- Botanical composition
- Pond quality
- Headwater stream quality
- Pollinator taxa
- Breeding birds
- Woodland and woody linear feature mapping
- Landscape photography
- Historic environment features
- Public footpath condition

EO is used to assess:

- Soil erosion features
- Broad Habitat extent
- Land cover change

Modelling and farmer practice surveys are used to assess:

- GHG



https://erammp.wales/en/nfs

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This approach is efficient as a single well-funded and integrated monitoring scheme enables ‘use and re-use’ of data for many reporting requirements e.g……

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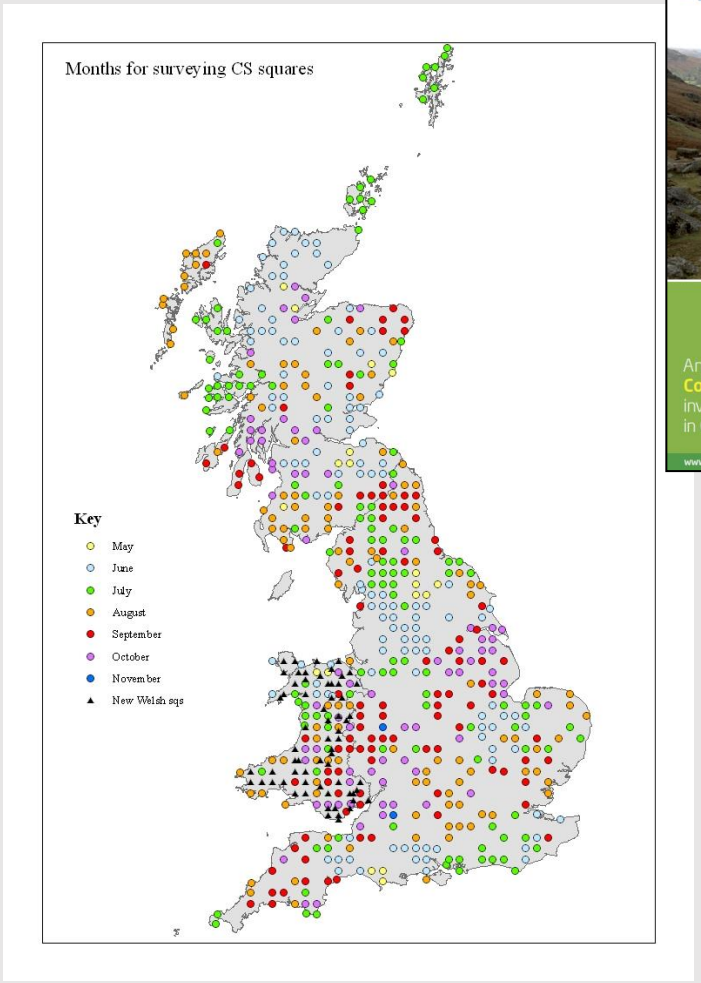
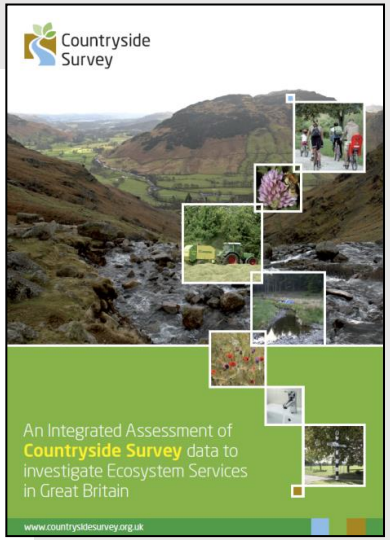
- CAP reporting
- State of Environment reporting (biodiversity, water, soils, landscape quality, cultural features..)
- Other policy outcomes e.g. ourcomes from a new planned ‘National Forest’
- Natural Capital Accounts
- GHG inventory (soil C data)
- Resilience Metrics
- Ground-truthing of EO
- Soil ‘Biobanks’ (frozen and dried soil archives) for emerging contaminants and molecular work
- Parameterising and testing models
- Research questions

https://erammp.wales/en/nfs

This builds on ‘Countryside Survey’ – a National topsoil monitoring in Great Britain since 1978 to present day

- Stratified random design
- 2800 sampling locations (595 1km squares x 5 random locations) (744 in LUCAS)
- Co-located with vegetation monitoring
- 0-15cm
- Wide range of biological, physical and chemical indicators including contaminants
- Soil function measurements (potential nitrogen mineralisation, soil respiration, microbial C efficiency)

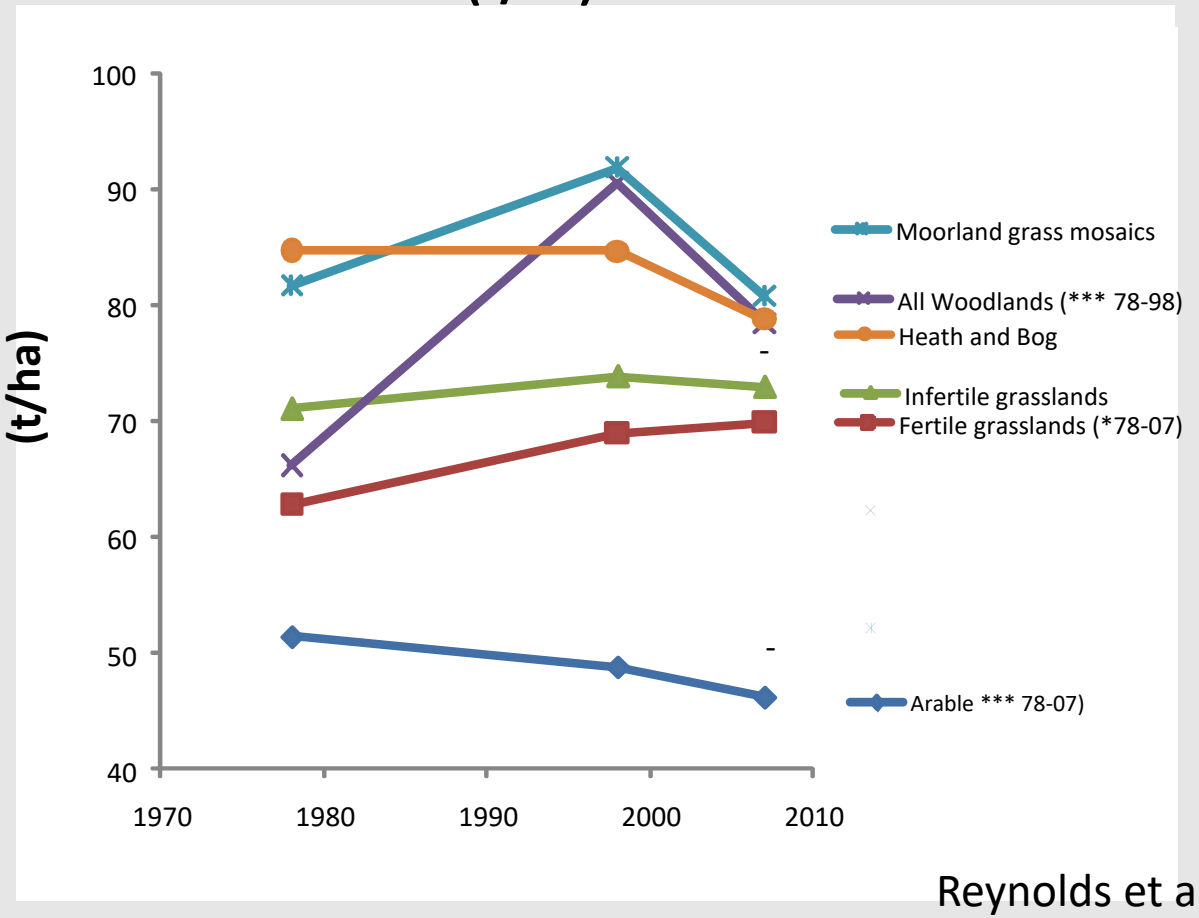




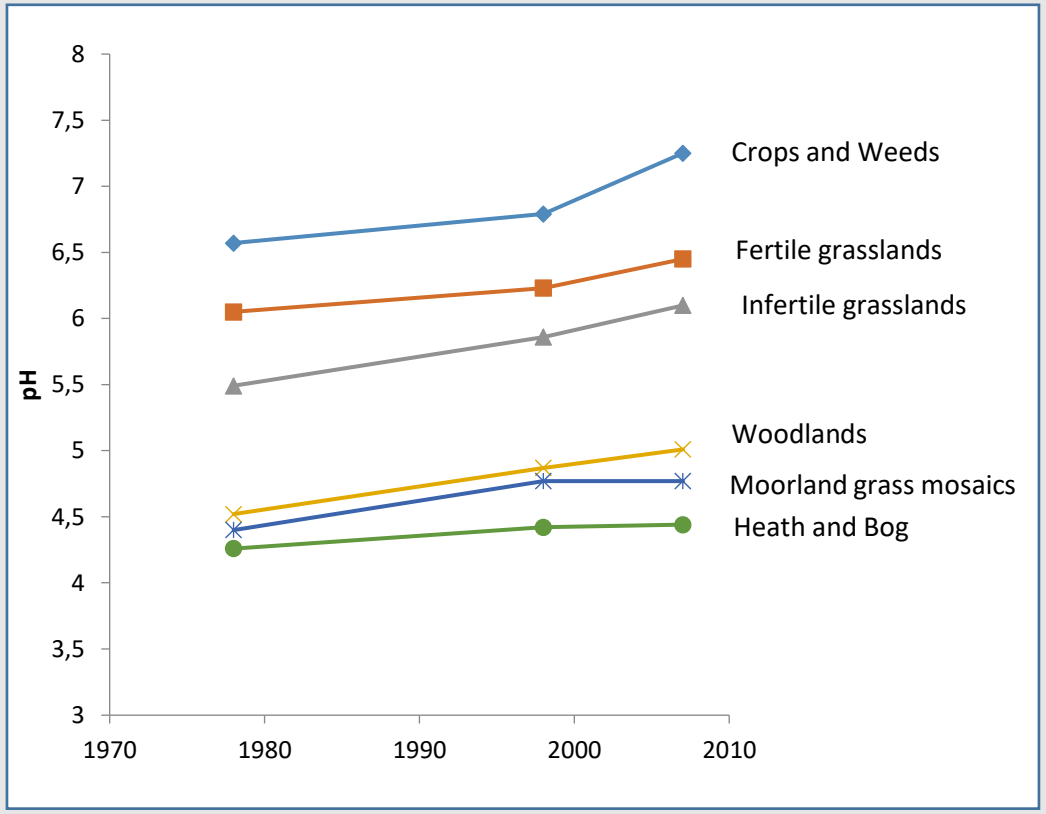
https://countrysidesurvey.org.uk/content/soils-report-2007

Data has clearly shown the outcome of policy failures (e.g. ongoing loss of SOC in arable soils) and successes (e.g. benefits of air quality policies for acidic deposition) over 40 years….

Change in topsoil organic carbon (t/ha) 78-07

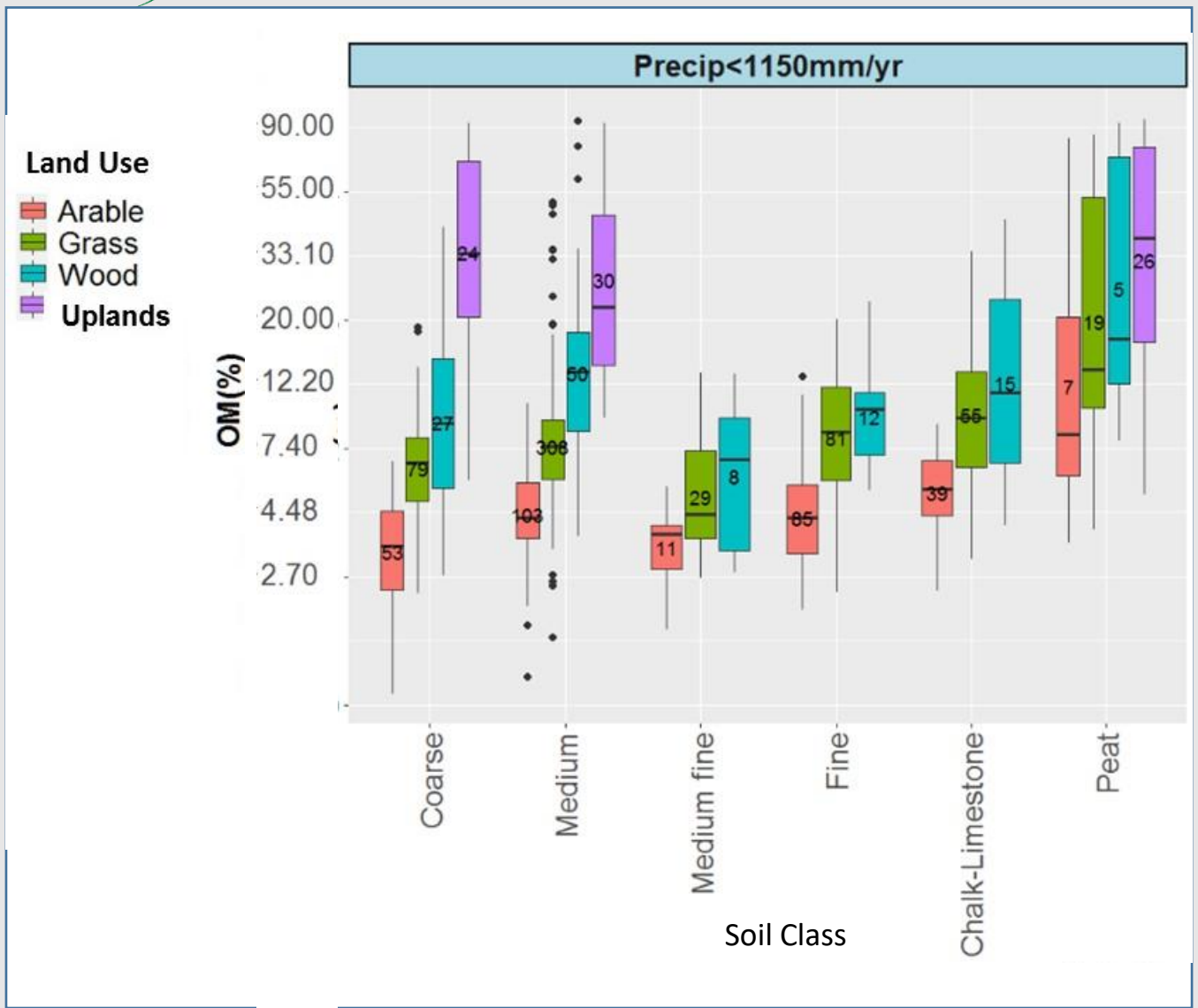


Change in pH (78-07) (All significant)



Reynolds et al (2013) *Vadose Zone Journal,* **12**.
https://countrysidesurvey.org.uk/content/soils-report-2007 for all data

The data can also be used to set benchmarks / targets by soil type, land use and climate as proposed by the mission



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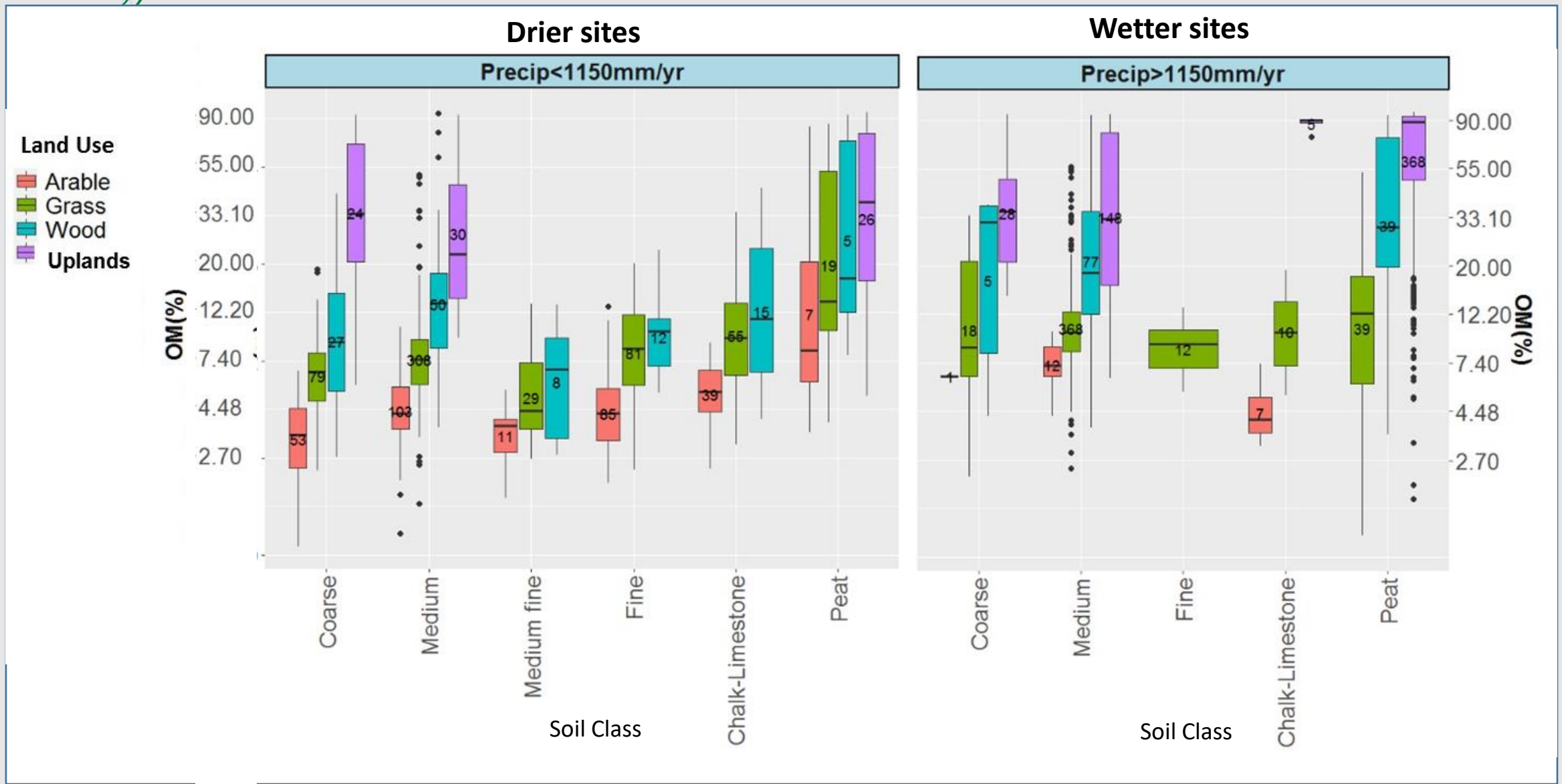
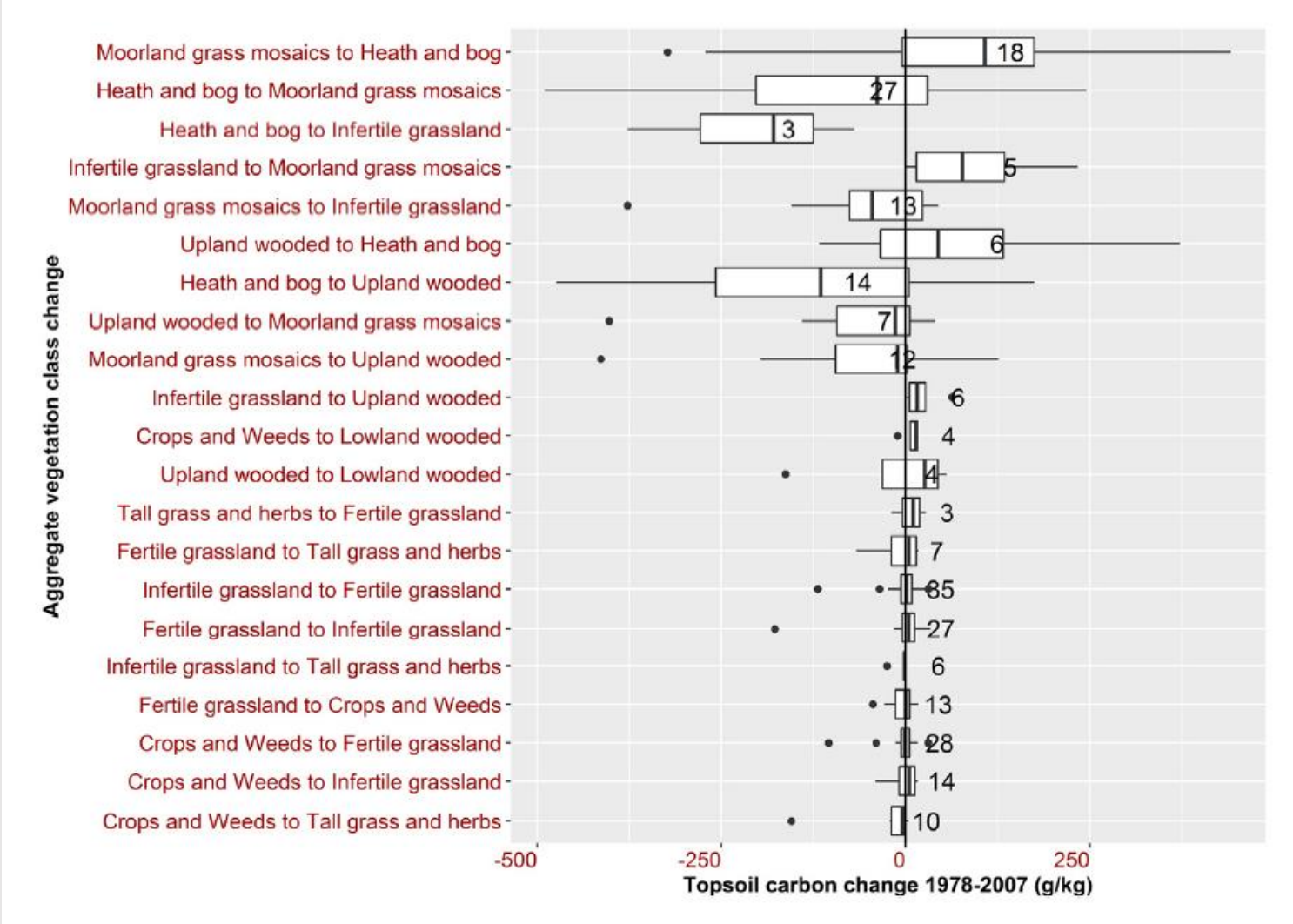


And evaluate the impact of habitat creation and restoration (or loss) from CAP on soil health



Thomas et al, (2020)
STOTEN 729

Question 5: Can remote sensing remove the need for in-field soil monitoring? No…. or at least not in isolation..

Operational

Direct measure: Erosion and gullies
Soil sealing

Indirect measure: Landcover and landcover change
Some management activities (e.g. cover crops)
Vegetation cover

Under development: Most need other information, modelling and/or ground data as all are indirect

- Nutrient status (needs crop and management info)
- Soil organic carbon (with modelling and ground data)
- Soil compaction
- Soil biodiversity
- Landscape heterogeneity

Unlikely or only at large regional scales

- Diffuse and non-diffuse pollution
- Contaminants
- Salinisation

Next steps for tracking change in soil health proposed in the EU mission Implementation Plan

Next steps for monitoring change in soil health across Europe (Mission Implementation Plan)

- Set-up technical support for cooperation and coordination of monitoring beyond agriculture to cover all soil types (incl. urban, alpine, forestry…);
- Develop a harmonised reporting structure (i.e. indicators; reporting classes, targets and thresholds, integration of indications (e.g. one out/ all out as in the Water Framework Directive or….?) etc;
- Promote new and/or revitalised national monitoring programmes and integration with LUCAS;
- Develop citizen and civic science approaches for soil assessment to contribute to increased soil awareness and literacy;
- Work with EU Soil Observatory and other data hubs to encourage use and re-use of data;
- Develop a harmonised Soil Health Report and Soil Health Passport to provide rapid and accessible confirmation of good soil practice;
- Work with R&I programme to develop next generation of soil indicators (including EO, microbiome etc), including their links to soil function and services/benefits, and a robust global soil footprinting tool

Ultimately… how are we going to leave our soils for the next generation?

"What we don't measure – we can't manage"
We need to recognise that is as true for soils as it is for our other natural resources.

My thanks and acknowledgement of shared work and ideas to:

Fellow members of the EU Mission Board for Soil Health and Food
JRC
UK Centre for Ecology and Hydrology (UKCEH) Countryside Survey and
ERAMMP colleagues.

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