LAND USE *for* NET ZERO HUB

PRESENTERS:

Prof. John Boardman
Dr Richard Smith
Prof. David Robinson
Dr Alejandro Dussaillant

Soils and Flooding Workshop

Workshop presentations by UK Centre for Ecology and Hydrology, Natural England, and University of Oxford

17th November 2025

UK Research and Innovation

Department for Environment Food & Rural Affairs

Department for Energy Security & Net Zero

Llywodraeth Cymru Welsh Government

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INTRODUCTION

- Welcome to the Soils and Flooding Workshop
- This workshop will be recorded, and outputs will be shared via email and through the LUNZ hub website.
- We will start with presentations from from our expert panel and then go straight into a discussion with questions. Please save your questions until the end of the presentation or put them in the chat and we will harvest them as we go through.

Agenda

Prof. David Robinson, Soil Scientist, UK Centre for Ecology and Hydrology - *Establishing context and evidence for the role of soils in Natural Flood Management (NFM)* 1

Dr Richard Smith, Technical Specialist, Environment Agency - *Illustrations of soil compaction and erosion causing localised flooding*. 2

Prof. John Boardman, Environmental Change Institute, University of Oxford, - *Runoff and erosion risks in arable systems.* 3

Dr Alejandro Dussaillant, Engineer and Hydrologist, UK Centre for Ecology and Hydrology - *Soil-based Nature-Based Solutions: How Regenerative Agriculture Practices monitoring evidence shows potential for flood risk reduction* 4

Discussion and Questions 5

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Establishing context and evidence for the role of soils in Natural Flood Management (NFM)

Prof. David Robinson

Soil Scientist, UK Centre for Ecology and Hydrology

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Establishing context and evidence for the role of soils in Natural Flood Management (NFM)

David A. Robinson,

UKCEH, Bangor

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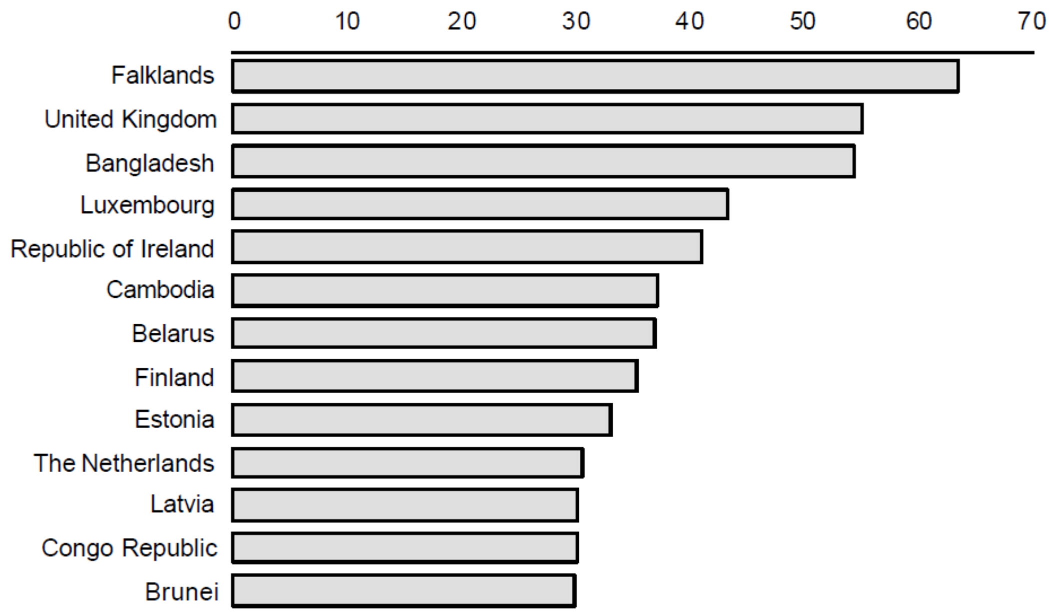
UK soils are inherently wet!

According to GLASOD, (2000) report by FAO the UK is ranked number 2 in the world for hydromorphic soils, these are soils that are wet in the soil profile for all or part of the year for example gleying. So, there is an inherent issue with wet soils in the UK.

FIGURE 1

Countries most affected by soil constraints: hydromorphy



Annual average precipitation has remained about the same, but we now get more in winter and less in summer

(Dadson et al., 2017)

Since 1760 the annual average amount of precipitation is about the same, but we now get more in winter and less in summer. Moreover, projections from the latest global and regional climate models do not suggest a systematic change in annual rainfall totals in the UK between now and 2080; There is likely to be some change in the spatial distribution of rainfall and higher rainfall maxima are expected.

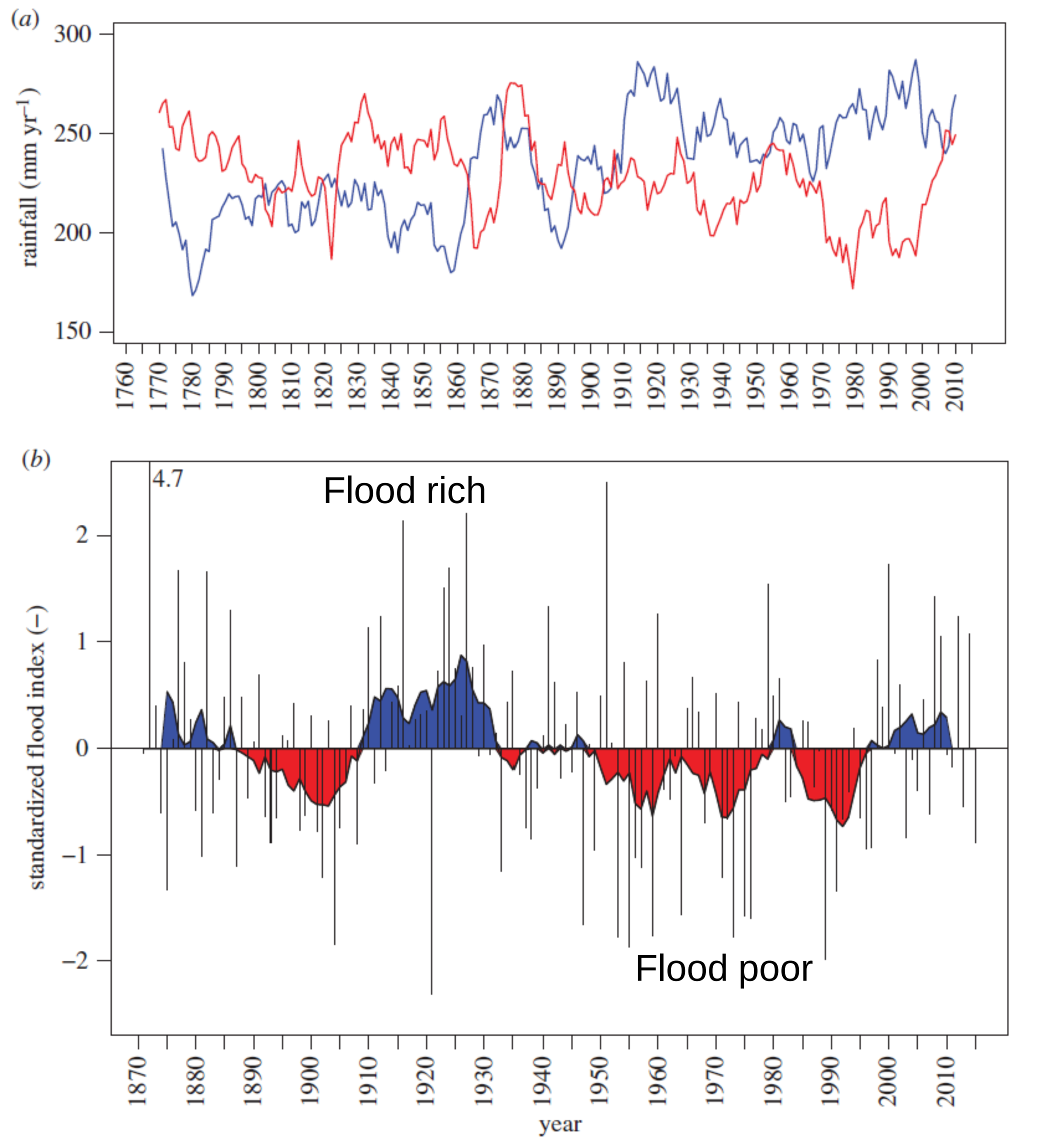


Figure 1. Climate variability and flooding. (*a*) England and Wales precipitation seasonality (1776–2015); the blue line shows winter (DJF) precipitation; the red line indicates summer (JJA) precipitation. Data from [4]; http://www.metoffice.gov.uk/hadobs/hadukp/. (*b*) Annual mean flood index (1871–2015). The blue and red shading shows flood-rich and flood-poor periods respectively Data from ref. [5]; https://crudata.uea.ac.uk/cru/data/lwt/.

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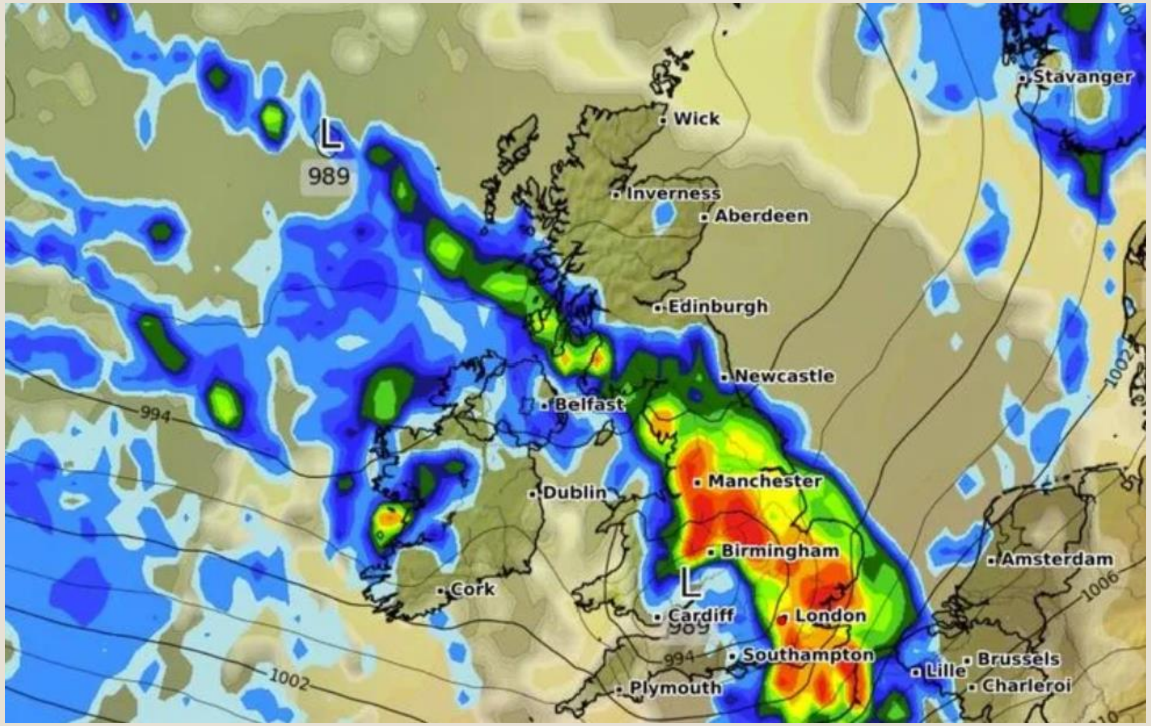
The number of 50mm storms between Oct to December has increased and will likely continue to increase.

(Cotteril et al., 2021)

An analysis by the Met office based on Observations showed that the frequency of extreme daily precipitation in the form of 50mm storms in October, November and December has already increased by 60% (95% CI: 44–76) in the UK between the beginning of the 20th and 21st centuries. The structure of these storms matters, in terms of peak intensity as this influences ponding and runoff due to infiltration excess.



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Evidence declines with scale

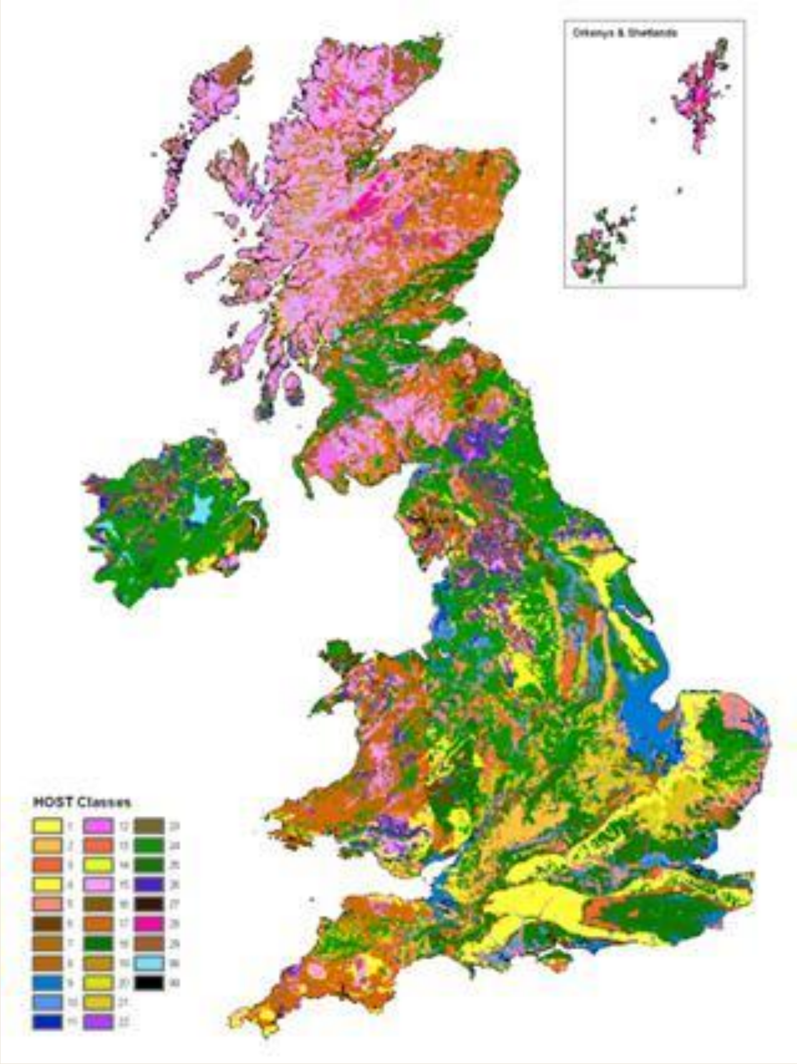
Scale is vital in interpreting the impact of NFM soil measures:

- strong evidence of impact at the hillslope and field scale,
- Some evidence of a reduction in flood peak and timing in small catchments, up to 1km,
- Less evidence for sub watersheds up to basins.

(Less evidence is collected)

Hydrology of Soil Types (HOST) can be a useful tool for determining where optimal areas are located for potential NFM measures but needs updating.

HOST



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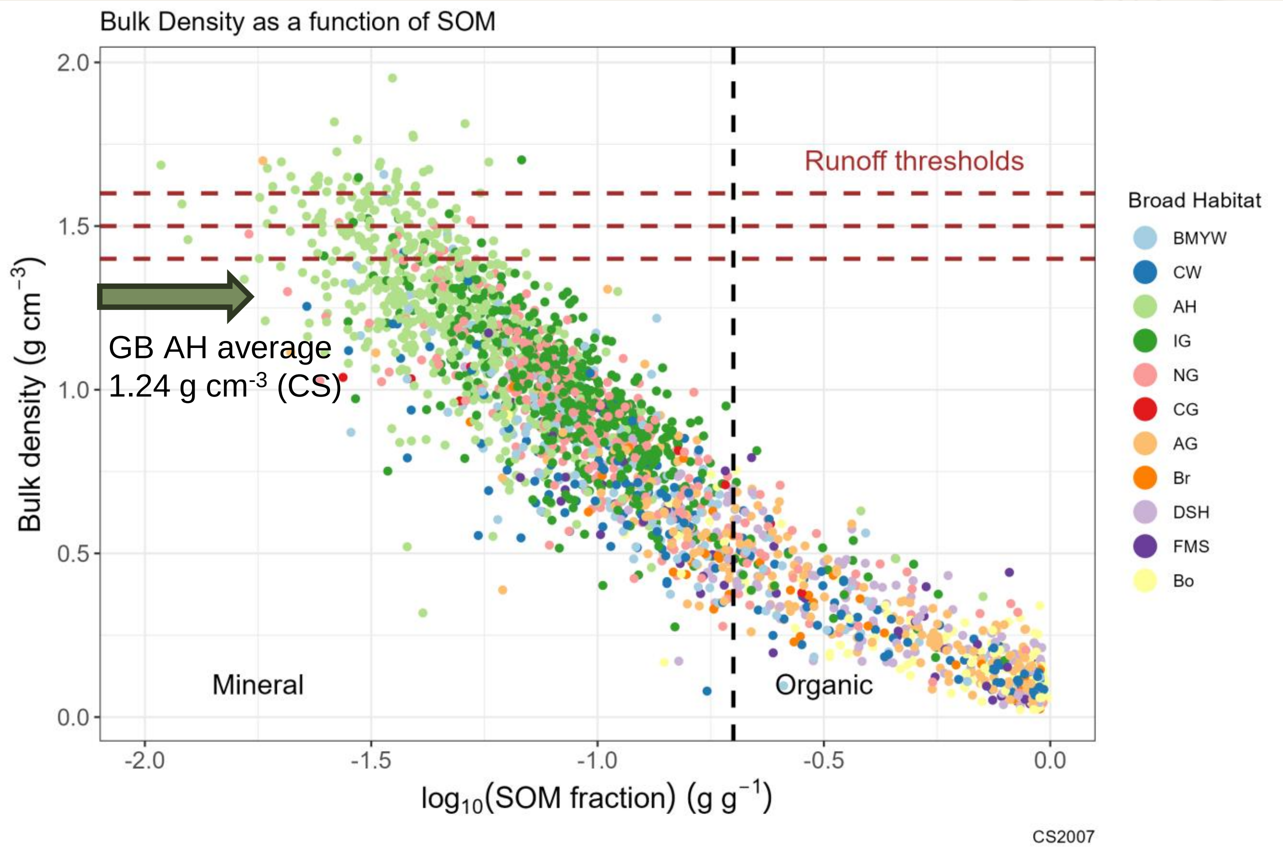
National soil data

While infiltration excess mechanisms are soil type dependent, more than half of UK soils have some vulnerability to these mechanisms according to Countryside Survey.

Most soils with bulk densities above 1.5 g cm^{-3} are found in arable and horticultural farming systems that are low in soil organic matter and trafficked.

The most recent report from Countryside Survey indicates that topsoil organic carbon has increased in the last decade (Bentley et al., 2025), and we wait to see if porosity has increased accordingly.



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Illustrations of soil compaction and erosion causing localised flooding

Dr Richard Smith

Technical Specialist, Environment Agency

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What is the evidence base to support investment in soil-based solutions and practices for reducing flooding?

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The presentation will focus on:

- Soil hydrology and natural processes
- The research on how soil compaction and poor soil structure can increase runoff
- The scale of the problem in SW

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Surface water flooding

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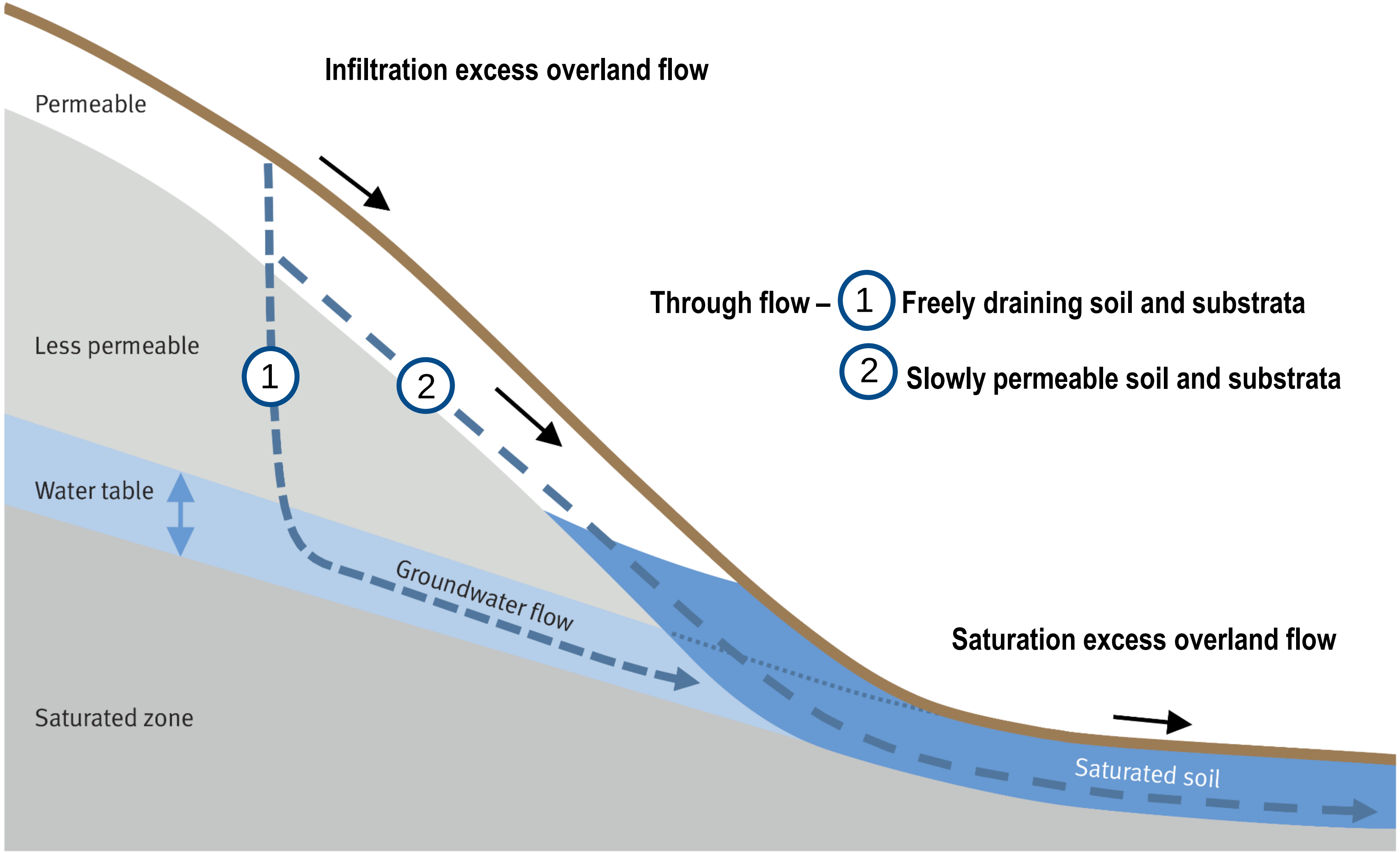
NATURAL RUNOFF PROCESSES



Risk of flooding from surface waters

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Risk of flooding from rivers and sea

Measuring runoff on freely draining soils

Undersown	Chisel plough	Stubble	Cover crop
53 litres	1litre	228 litres	179 litres

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Poor soil structure vs good soil structure

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Simulating heavy rainfall and measuring runoff




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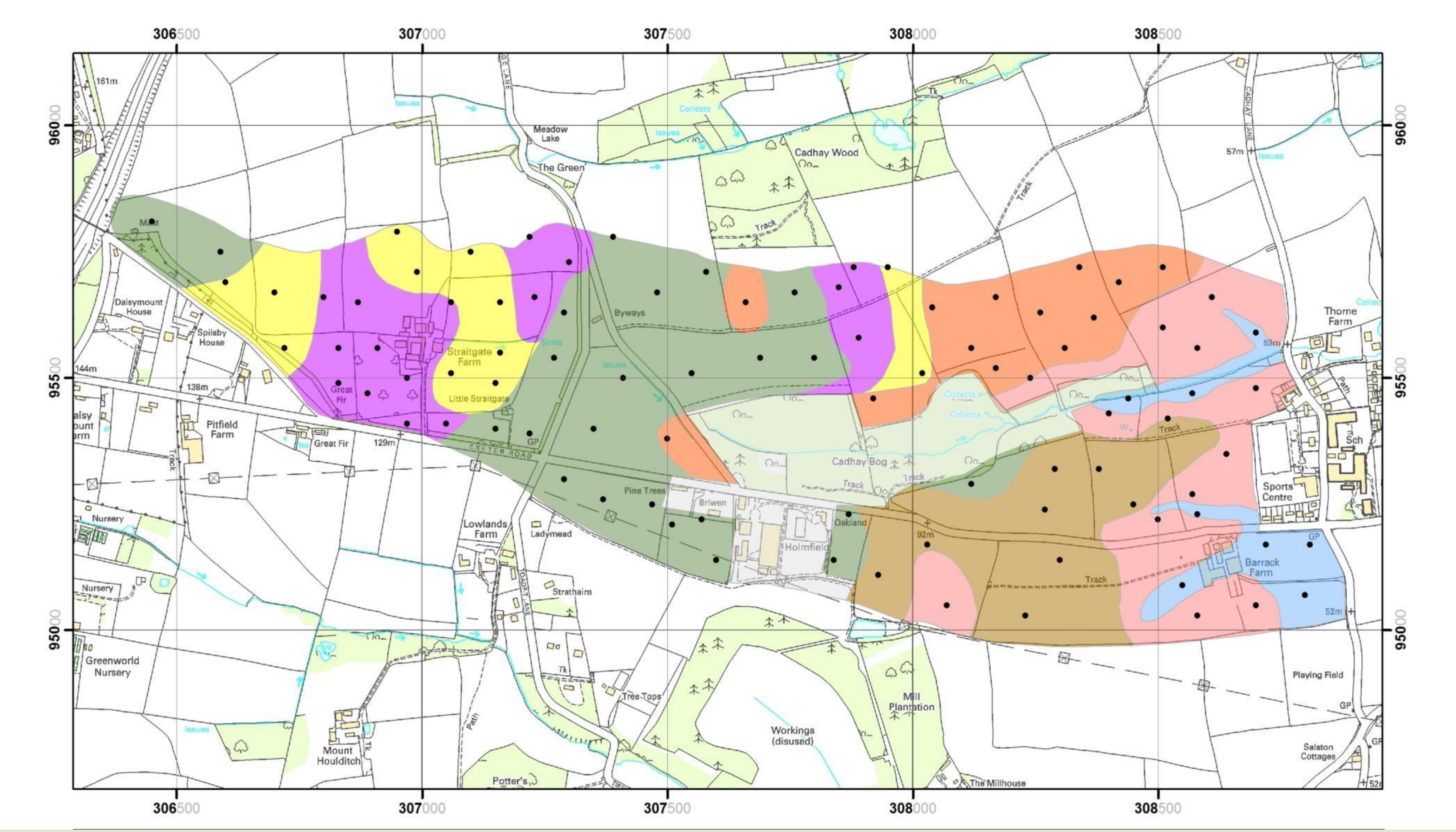
Does poor structure increase runoff?



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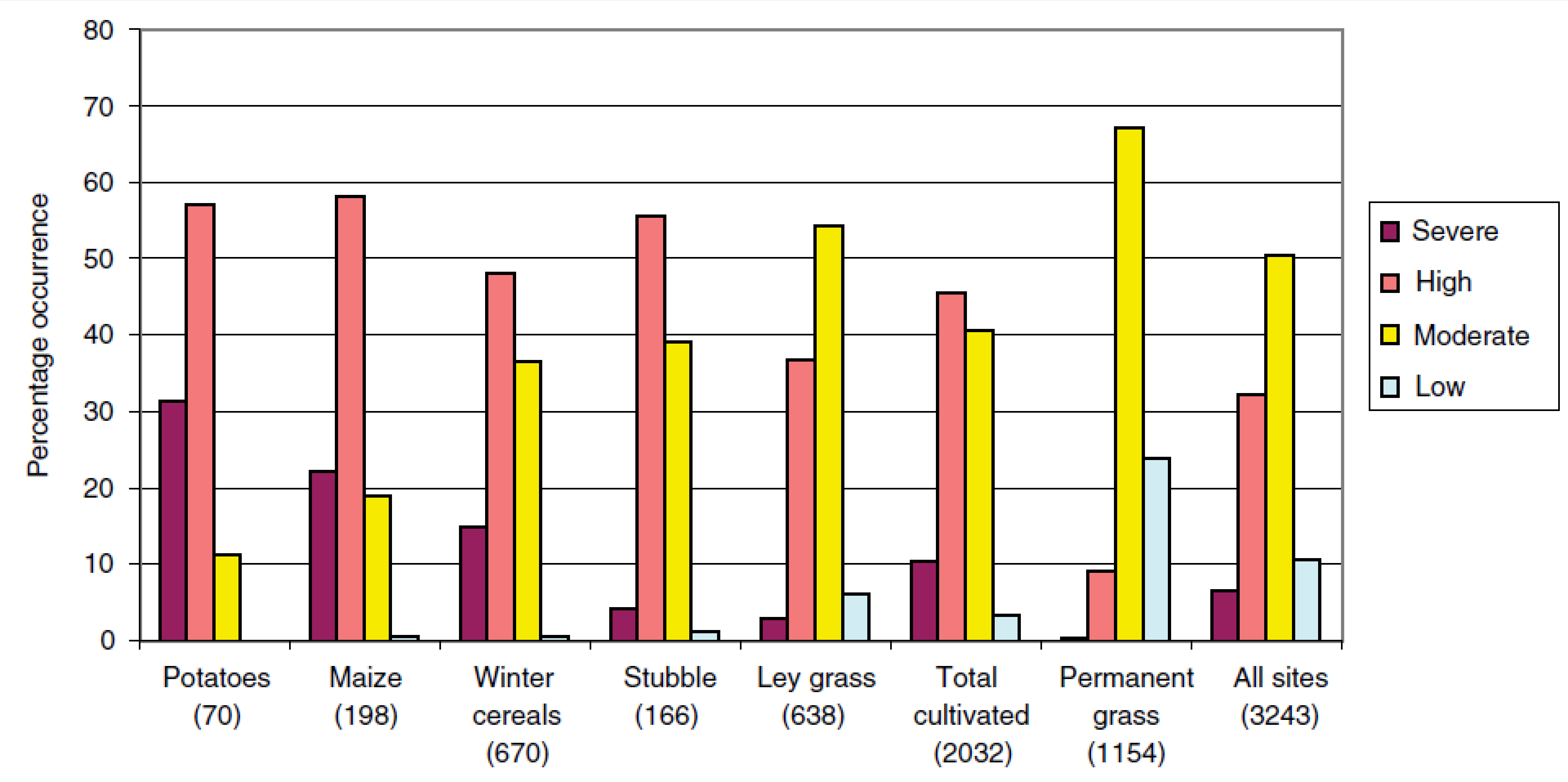

R.C. Palmer and R.P Smith, Soil Use and Management
doi:10.1111/sum.12068

Dealing with soil compaction

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Conclusion

- Poor soil structure can cause localised flooding

Conclusion

- Good soil structure can accept heavy rainfall on freely draining soils

References

For understanding the scale of soil degradation affecting runoff in SW England

Palmer, R. C., & Smith, R. P. (2013). Soil structural degradation in SW England and its impact on surface-water runoff generation. *Soil Use and Management*, **29**, 567–575.

For understanding about measuring runoff and the control of soil erosion in maize

Clements, R. O., & Donaldson, G. (2002). Soil Erosion Control in Maize. R & D Technical Report P2-123/1. Environment Agency.

For understanding about rainfall simulation and measuring runoff associated with heavy rain

Howden, N & Deek, L (2007) Soil Examination, Rainfall Simulation and Soil Runoff and Infiltration Experiments following a flood event in the Boscastle area. Draft Report to the Environment Agency

For guidance on soils and natural flood management

Smith, R,P. (2007). Soils and Natural Flood Management in Devon and Cornwall. Document published by the Catchment Based Approach (CaBA).

A summary case study investigating lessons learnt dealing with soil erosion and flooding

Smith, R. and Boardman, J. (2025) ‘Muddy flooding from soil erosion associated with maize cultivation: a case study from East Devon, UK’, *Soil Use and Management*, 41, 1, e700038. http://doi.org/10.1111/sum.70038

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Runoff and erosion risks in arable systems

Prof. John Boardman

Environmental Change Institute, University of Oxford

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What would we like policy makers to understand about soils and flooding?

1. Vulnerability of certain areas to erosion and flooding

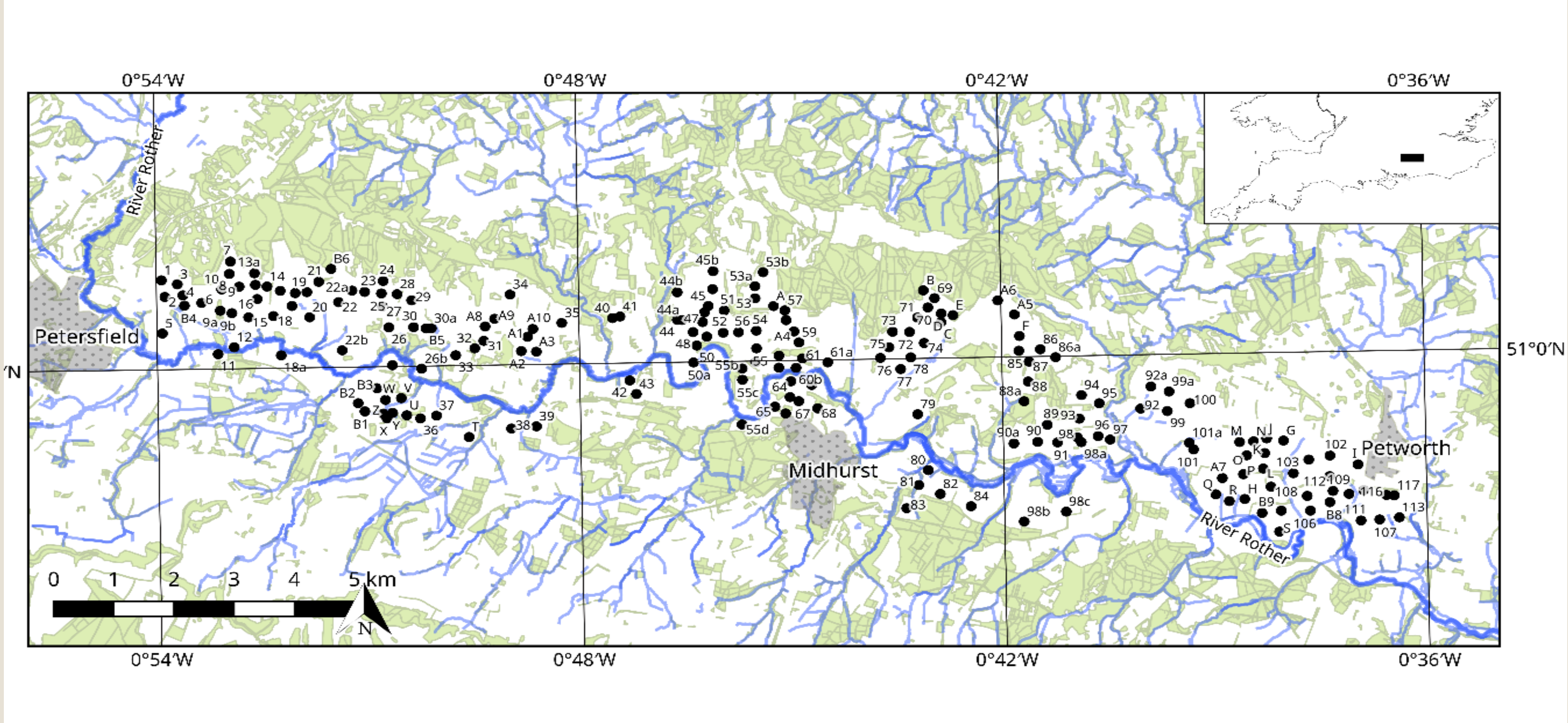
2. Off-site damage by muddy runoff strongly related to connectivity

3. Farmers may ignore even well-targeted advice

4. Well-planned mitigation measures do work but have to be judged over time

- I will use work in East and West Sussex over the last 45 years to illustrate my points

The Rother valley: fields with a history of erosion since 1987



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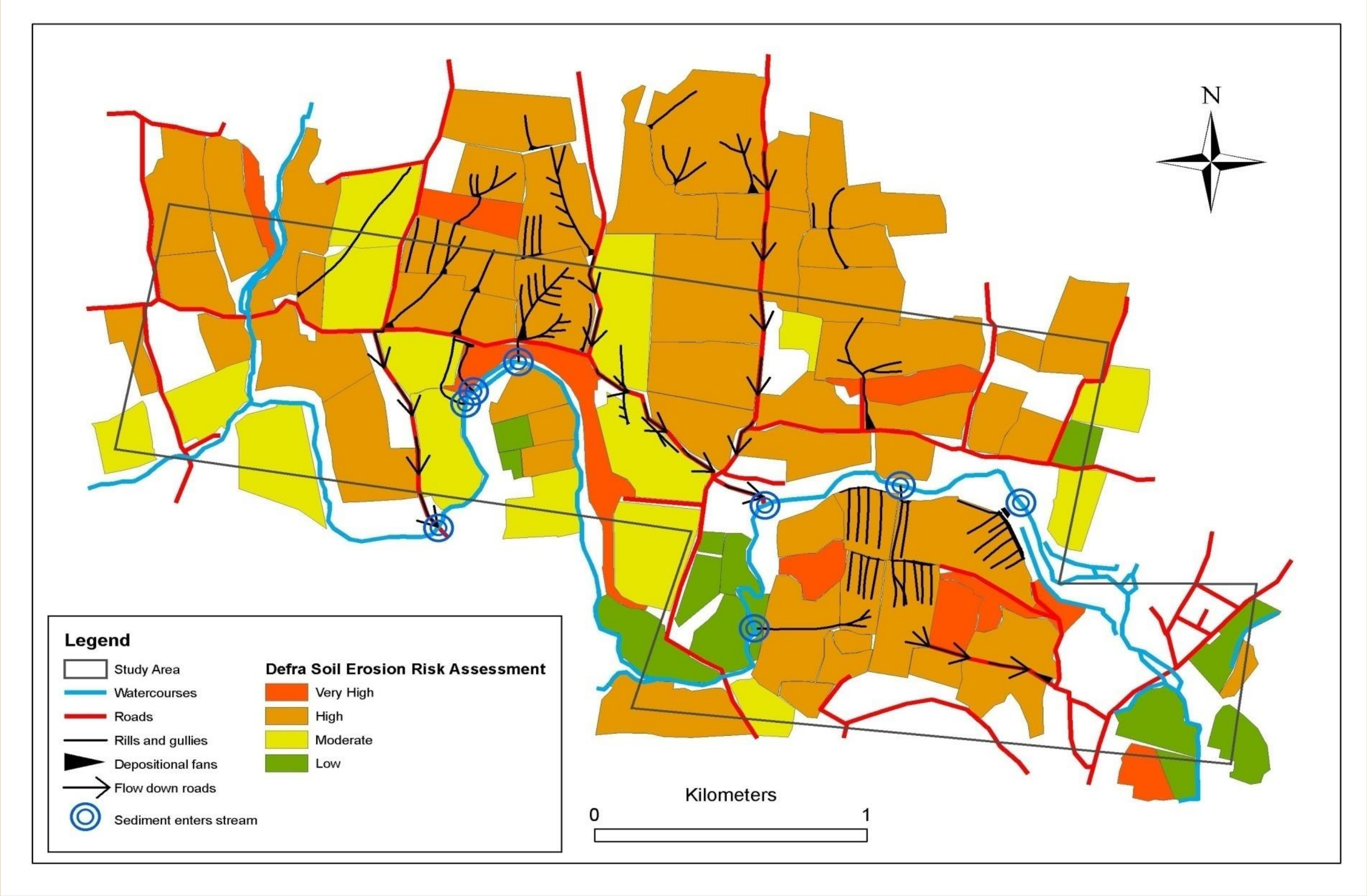
The distribution of eroding fields is not random:

- It relates to highly erodible soils, vulnerable crops (pots, maize, winter cereals etc), slope and farming practices
- Unfortunately, 66% of these fields are potentially connected to freshwater systems and are therefore resulting in excessive pollution and high off-site costs
- If we want to address the issue of off-site damage (muddy flooding, freshwater pollution etc) we have to look at connectivity
- What has been poorly researched is the question of how many and where mitigation measures are needed to have significant impact

Soil erosion risk assessment (Defra): crops on vulnerable, high-risk sites (Midhurst, West Sussex, 2006). Note entry points of muddy runoff into river



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Role of sunken lanes in West Sussex: connecting runoff from fields to the river

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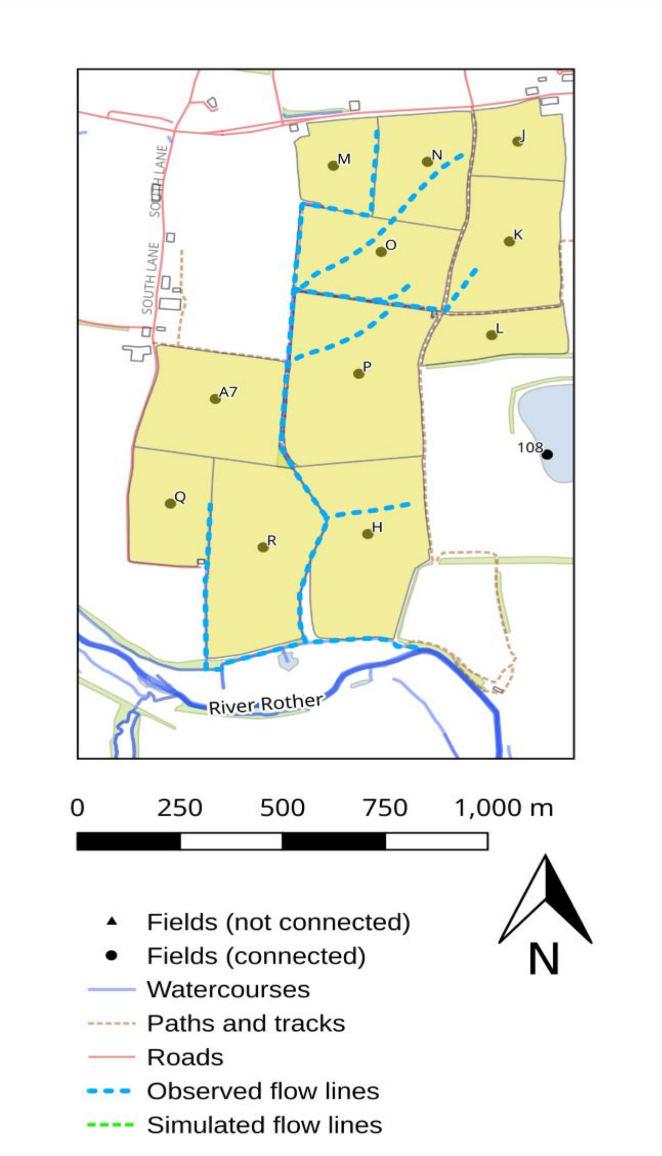
Connectivity between fields and the river



- Observed connections between fields and the river (flow of water and sediments) near Petworth, West Sussex
- Note role of ditches and drains and pervious field boundaries

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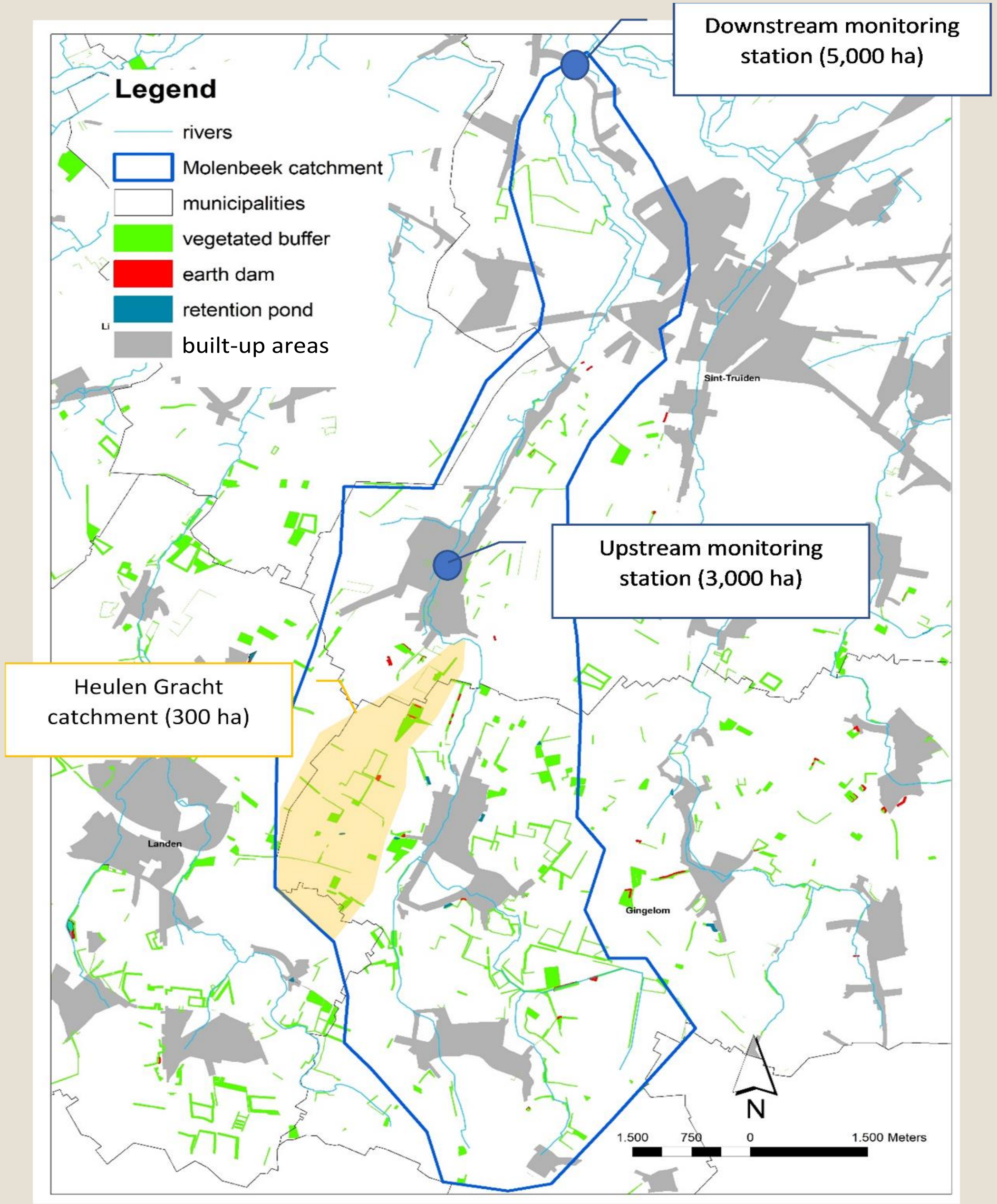
Mitigation measures: what effect do they have on sediment reaching a river?

	1996-2005	2006-2014
Downstream site	43.1 mg/l	28.4 mg/l
Upstream site	58.8 mg/l	17.5 mg/l



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Do farmers follow advice? Maize stubble 5% cover: 10 November

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Non-compliant fields

Field no.	Condition: 10 October 2015	Condition: 10 November 2015	Condition: 3 December 2015	Condition 20 January 2016	25 February 2016
38	Maize 2m high	Maize stubble, little debris 5 - 10% cover, some wash	No change	No change	No change; very compact; no weeds
T	/	Maize stubble, no debris, 5% cover, some wash, comp	No change	No change	5-10% cover; wash, compact, no weeds
37	Maize st.bare.comp	Maize stubble, no debris, 5% cover, some wash, comp	No change	No change	Being ploughed
36	Maize st.bare.comp, wash	Maize stubble, no debris, 5% cover, some wash, comp & small rill	No change	No change & sediment to the road	Being ploughed
U	/	Maize stubble, no debris, 5% cover, some wash, comp & rills (N end is win cer)	No change	No change but strip ploughed at top of hill	ploughed
V	/	Maize stubble, no debris, 5% cover, a little wash, comp	No change	No change	ploughed
W	/	Maize stubble, no debris, 5% cover, some wash, comp	No change, with some standing water	No change	ploughed
X	/	Maize stubble, 20% cover, some wash, comp	No change	No change	No change
Y	/	Maize stubble, 20% cover, some wash, comp	No change, with some standing water	No change	No change
Z	/	Maize stubble, 5% cover, some wash, comp	No change	No change	No change
76	Maize st, bare	Maize stubble, no debris, 5% cover, comp (wheelings); Crusted interills	No change	No change, small rills on slope	No change, some rills and wash on slopes
75	Maize st. bare	Maize stubble, 10% cover, some wash, comp (wh); Crusted interills	No change	No change, small rills on slope	No change; spraying today (weed kill?)
72	Maize st. bare	Maize stubble, 5% cover, some areas with weed, comp (wh) Crusted interills	No change	No change, small rills	No change

Risk of erosion, runoff and flooding in arable UK, largely in autumn/early winter with coincidence of bare ground (winter cereals etc) and moderate/heavy rainfall. This field eroded 6 times in 10 years.

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Conclusions

- Accept that some (easily identified) sites are high risk in terms of runoff and erosion
- Better educate farmers and penalise those that ignore advice
- Address connectivity issues with mitigation measures
- Monitor effectiveness of measures especially in terms of freshwater pollution

References

For mitigation measures and their effect on sediment to river:

Boardman, J., Vandaele, K. 2019. Managing muddy floods: balancing engineered and alternative approaches. *Journal of Flood Risk Management* 13(1) DOI: 10.1111/jfr3.12578

For the importance of connectivity and the role of sunken lanes in the hydrological system:

Boardman, J. Vandaele, K., Evans, R., Foster, I.D.L. 2019. Off-site impacts of soil erosion and runoff: why connectivity is more important than erosion rates. *Soil Use and Management* 35(2), 245-256 DOI: 10.1111/sum.12496

Boardman J. Shepheard, M., Walker, E. and Foster I.D.L. 2009. Soil erosion and risk assessment for on- and off-farm impacts: a test case in the Midhurst area, West Sussex, UK. *Journal of Environmental Management* 90: 2578-2588

Boardman, J. 2013. The hydrological role of 'sunken lanes' with respect to sediment mobilization and delivery to watercourses with particular reference to West Sussex, southern England. *Journal Soils and Sediments* 13(9), 1636-1644

For the South Downs and the risks of winter cereals:

Boardman, J. 2003. Soil erosion and flooding on the South Downs, southern England 1976-2001. *Transactions Institute British Geographers* 28(2), 176-196

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SSN Nov 17 2025

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HOW DO SPONGE MEASURES WORK?: Water Retention Indicator Framework and Application to Agricultural Nature-based Solutions – recent & ongoing research





Alejandro Dussaillant
Hydrology, Nature-based solutions

Gareth Old
Hydro-geomorphology

Ponnambalam Rameshwaran
Hydrological & hydraulic modelling

James Blake
Soil hydrology

Neeraj Sah
Field hydrology

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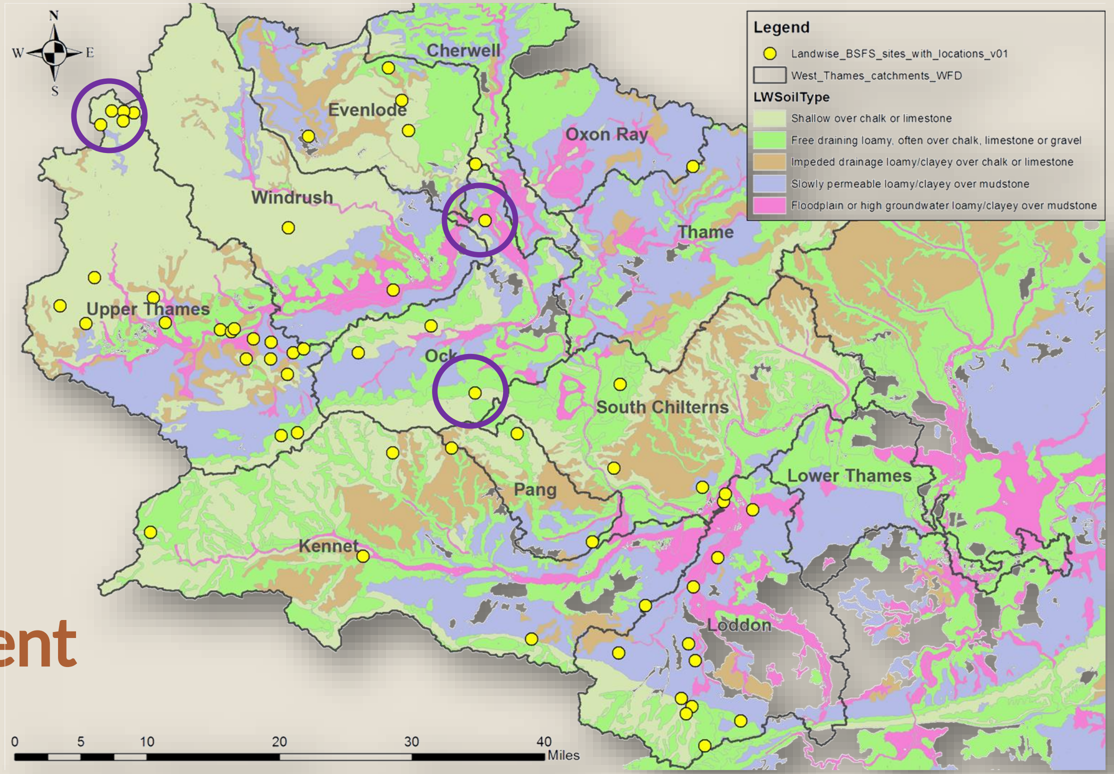
PAST LANDWISE PROJECT (2019-2022): SELECTED KEY RESULTS

LANDWISE field surveys:
How land use and soil management affects soil properties, with implications for flood risk

UK Centre for Ecology & Hydrology,
University of Reading, British Geological Survey,
Forest Research & Partners (Farm Advisors and Working Group)

James Blake (WP2 Lead), Emily Trill, Alex O'Brien, John Robotham,
Pete Scarlett, Gareth Old & Ponnambalam Rameshwaran (UKCEH)

Field Survey Overview



Measure soil physical properties (+ land use/management questionnaire)

Measure soil hydrological / hydraulic properties

Broad-scale survey of 164 fields

- Measure **properties of soil** that influence storage of water below ground: *bulk density (porosity), texture, structure, organic matter (+ water content, + vegetation).*
- Focus on **soil surface** (top 50 mm)

Detailed survey of 3 locations (7 fields)

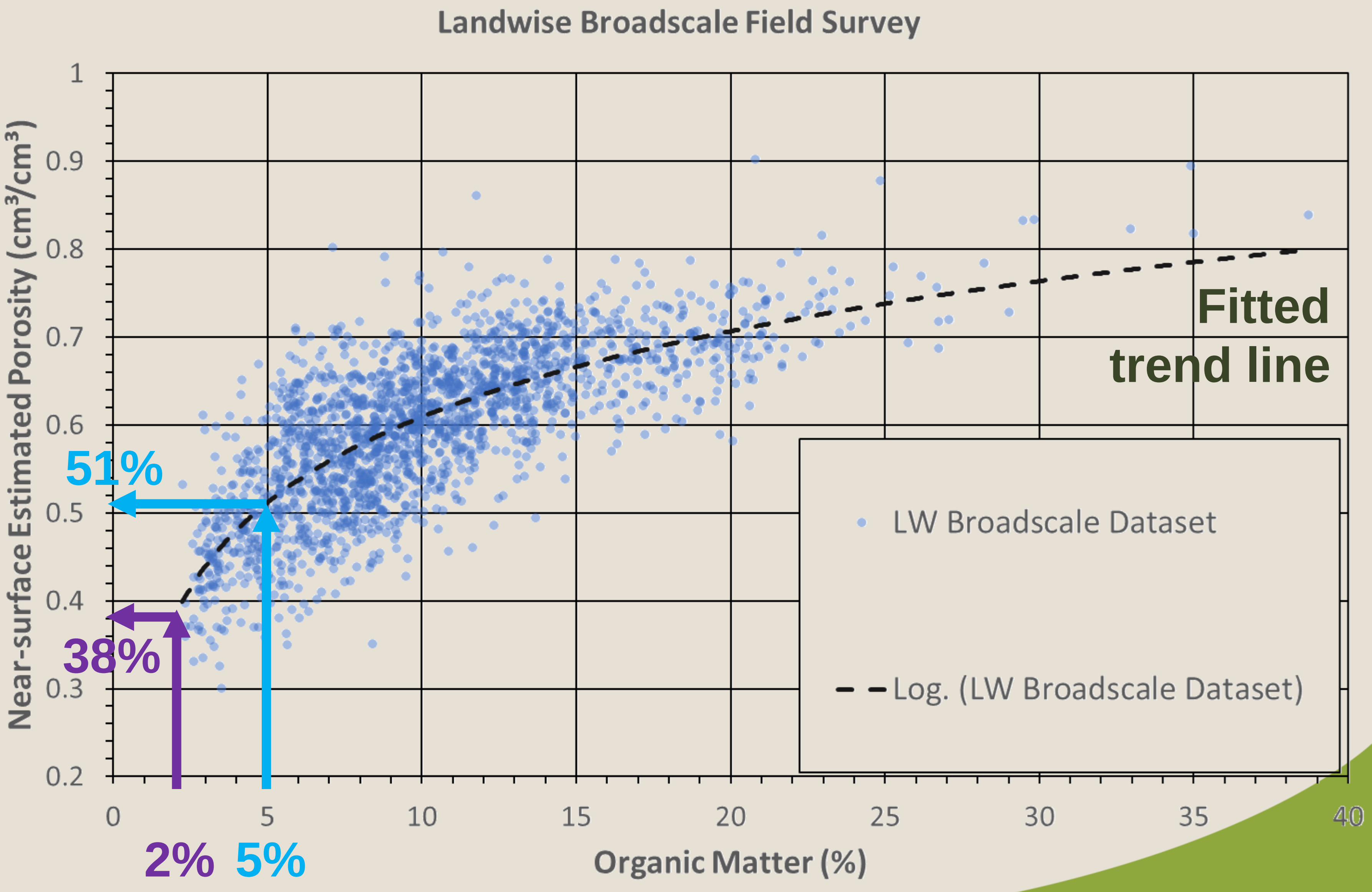
- Measure **properties of soil, infiltration** and **water storage** over time: *infiltration, hydraulic conductivity, soil moisture retention as well as bulk density, organic matter*
- Measure changes in **soil water** across larger areas and with depth

Broad-scale field survey – example field observations

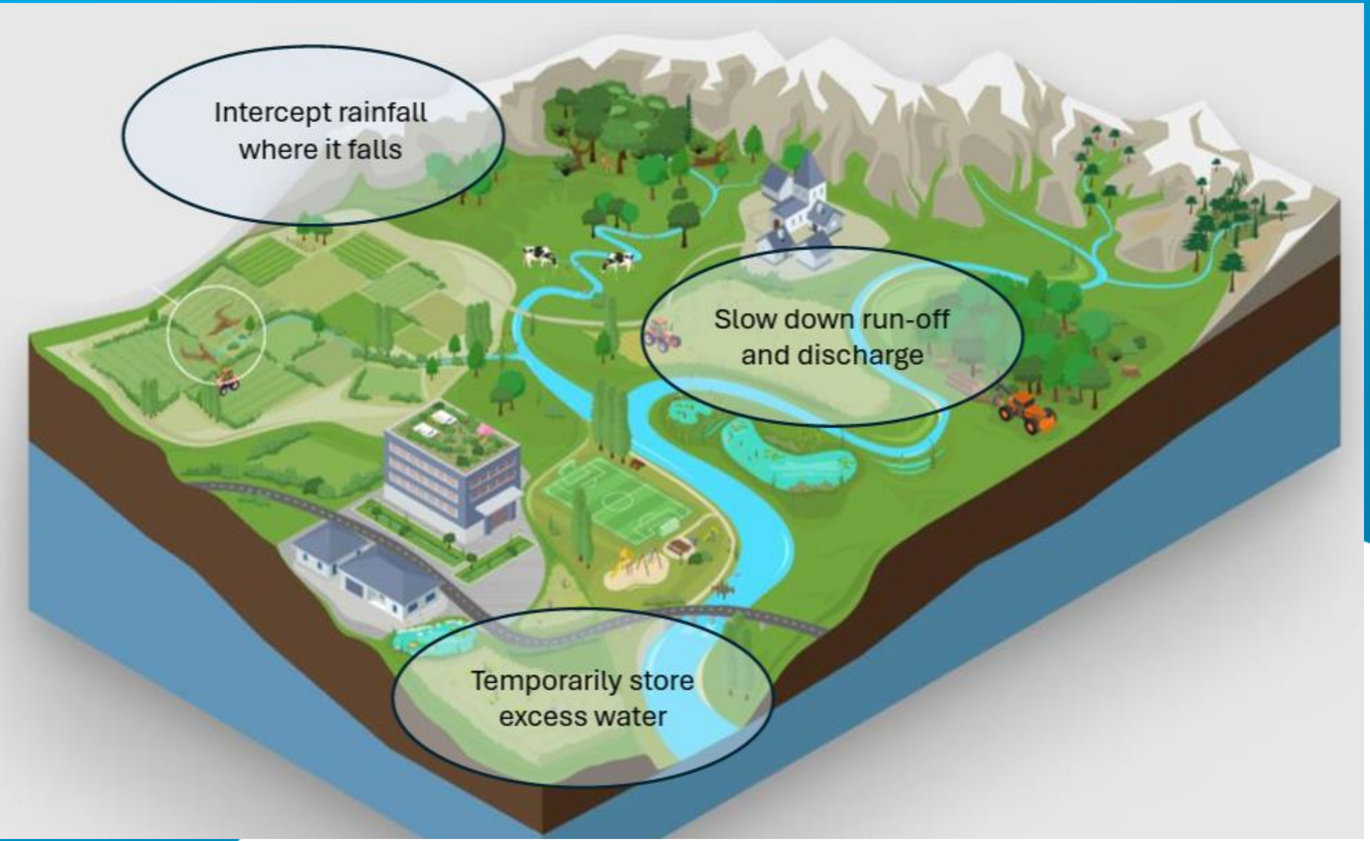
- Importance of soil surface condition - January 2020 (River Loddon catchment)
- Heavy clay soil
- Very near-surface saturated - water rapidly ponds and runs off, but deeper soil remains unsaturated (red arrow)

Broad-scale field survey – soil porosity & organic matter

- Increasing soil organic matter content increases soil porosity
- Points represent full range of field conditions (infield, trafficked and margin)
- If organic matter is 'low' (1-2%) to 'medium' (2-4%), modest increases can significantly increase porosity -->



1. Accelerate towards solutions that **improve the sponge functions** (Intercept/Disconnect, Store, Slow water) of soil, groundwater, and surface water landscapes.
2. Upscale individual "sponge measure" solutions into overarching **landscape scale "sponge strategies"**.

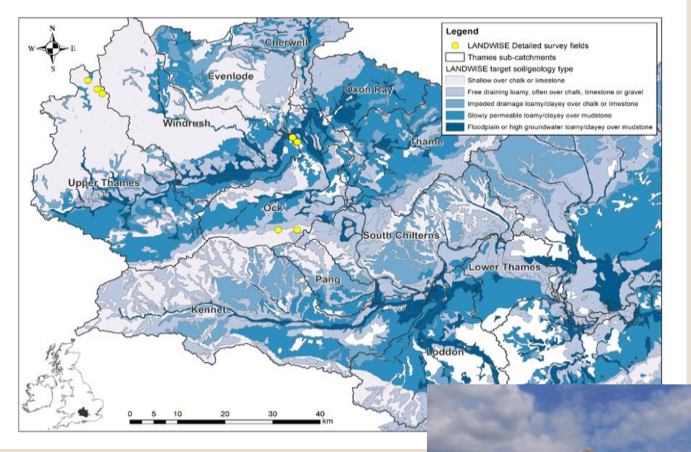


Funded by the European Union

UK Research and Innovation

www.spongescapes.eu and www.spongeworks.eu

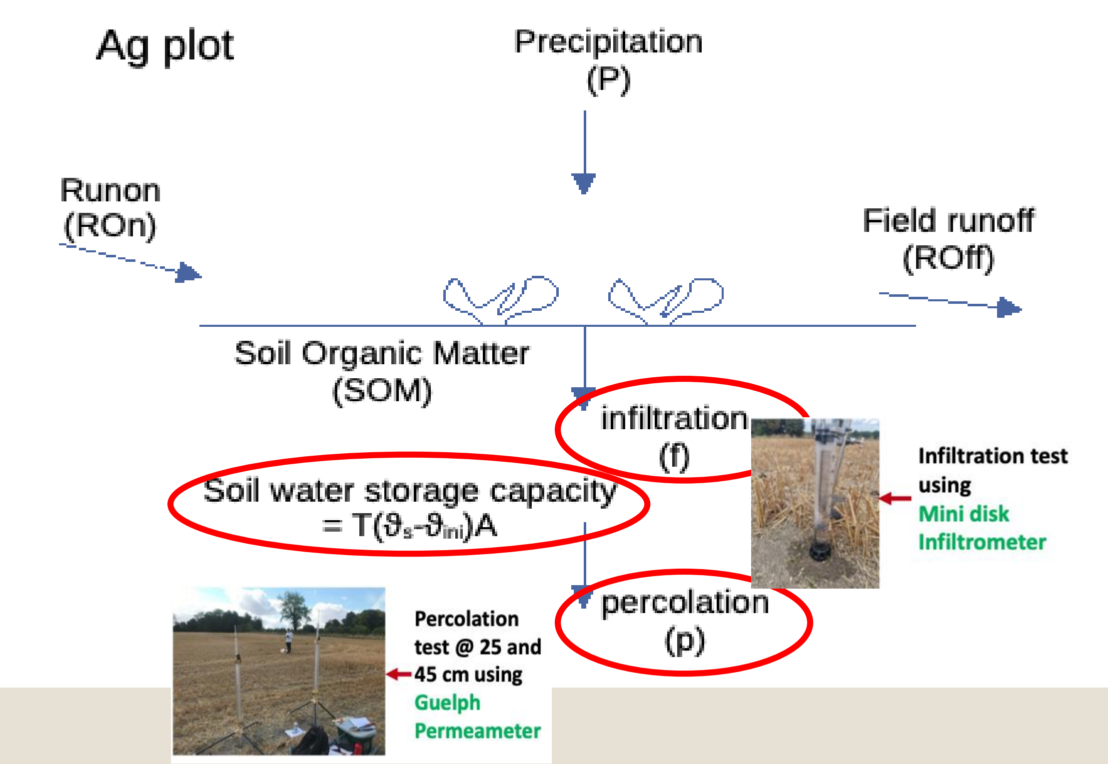
Upper Thames agricultural sites



Selection of LANDWISE (LW) NFM (2019-2022) sites

- Traditional rotational crop
- Regenerative ag practices (in-field buffer strips, cover crop, controlled traffic, soil amendments)
- Wooded versus grassland

- Key environmental challenge: mostly water-logging
- Co-benefit(s) studied: Soil Organic Matter increase



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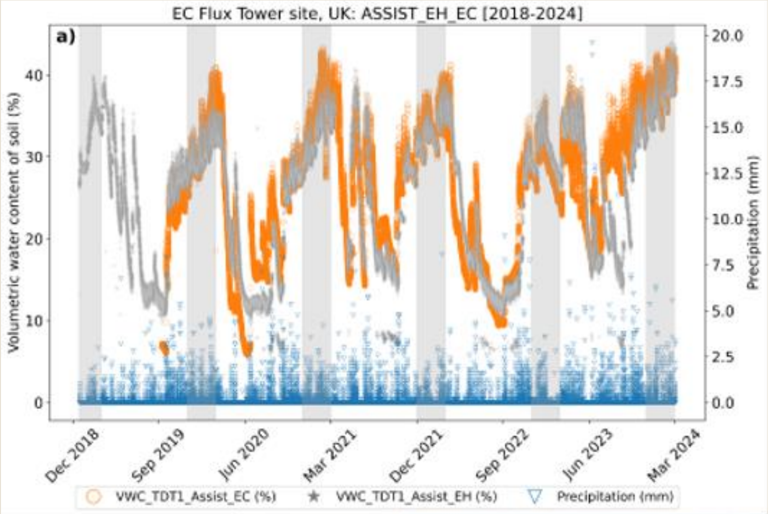
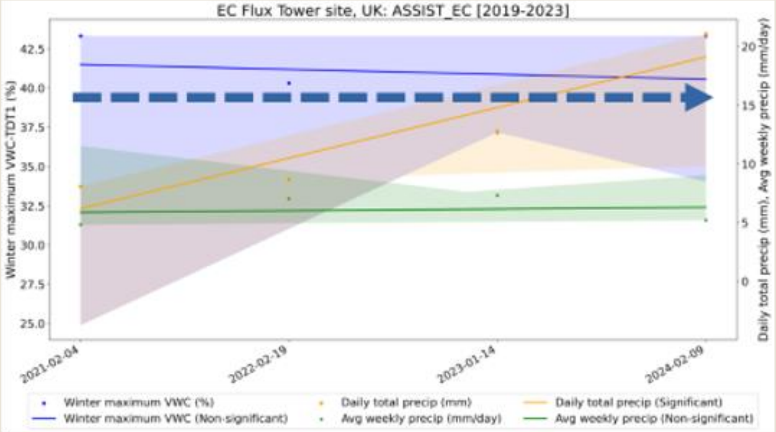
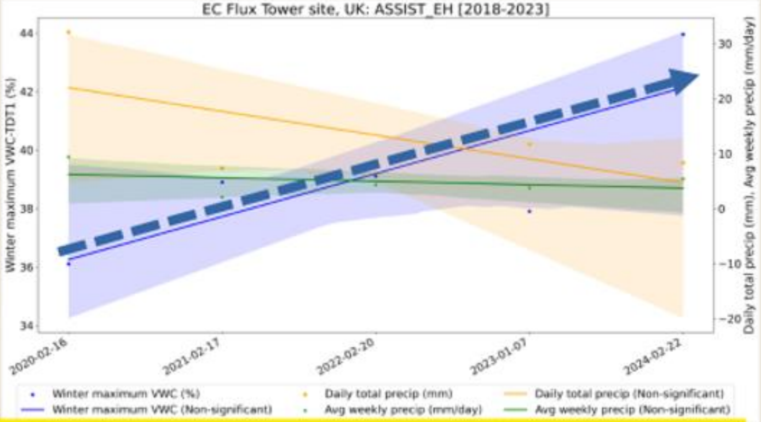
Some Preliminary Results, and Implications

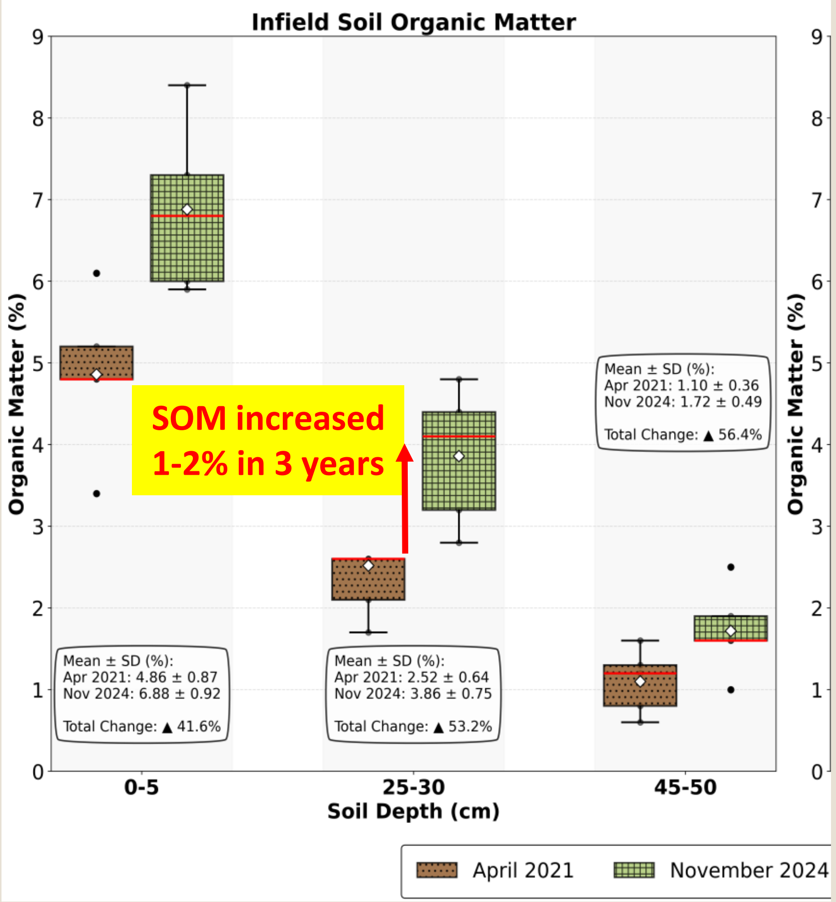






Regenerative ag practices (ASSIST-EH site) are:
- cover crop
- buffer strips
- controlled traffic

Note: an extra 5% of VWC capacity in 1m-deep soil in a 1ha field amounts to an extra 500 m³ of storage!



(not shown here: also increased soil hydraulic conductivity in regenerative agriculture sites)

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Working with Natural Process

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Working with Natural Processes & Nature-inspired/based Solutions | General | Microsoft Teams

- Process understanding: monitoring, analysis, modelling (all of us really)
- Evidence synthesis and ground monitoring (ADJ, JB, NS, PR, GO mostly)
- Remote sensing for flooding and soil moisture: satellite workflows (AC, BB, VM, CG), drone proof-of-concept methods (CG, NE, CL)

Alejandro Dussaillant
Hydrology, Nature-based solutions

Gareth Old
Hydro-geomorphology

Ponnambalam Rameshwaran
Hydrological & hydraulic modelling

Amulya Chevuturi
Hydro-climatology

Burak Bulut
Hydro-analysis

Vasilys Myrgiotis
Environmental Modelling

James Blake
Soil hydrology

Neeraj Sah
Field hydrology

Cedric Laize
Hydro-ecology

Nick Everard
Hydrometry

Charles George
Earth observation

Strengths	Weaknesses
S1. Growing number of regenerative agriculture exemplars. S2. Improving soil health provides multiple benefits (improved crops, livestock, C, water). S3. Once adapted, no going back to previous land (mis)management practices.	W1. Need more exemplars from low-mid income farmers. W2. Need better technical guidance to avoid costly decision/investment mistakes. W3. Risk of large initial failures making farmers/landowners revert to less sustainable practices.
Opportunities	**Threats**
O1. New funding (e.g., ELMS 2.0 in UK?). O2. Water industry funds to protect resource (e.g. Smart Water Catchment funds in UK). O3. Regenerative ag produce premium prices.	T1. Uncertainty on terms of new funds (ELMS). T2. Water companies under increased financial stress (including from climate crisis). T3. Increasing cost of living.

Guided Discussion and Questions

- How do soil type, soil properties and soil management influence susceptibility to flooding?
- What are the strategies (including nature-based solutions) that can help reduce or mitigate flooding and flood risk?
- In what areas could government help, in terms of policy or funding, and where might it look to do this most effectively?
- Are there policy or research gaps that need to be filled?
- How strong and/or useful are links between policymakers and private sector stakeholders – such as water companies etc. with respect to flood / flood risk?
- How do we build evidence to support investment in soil-based solutions?
- Are there any decision support tools or early warning systems that can help alleviate flood risk?

Future workshops

A series of workshops that explore the theme of Soil and Water:

1. Soils and Flooding

2. Soils and Drought

3. Soils in the Private Sector

Thank you

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