LANDWISE NFM

How soil management and land use affects soil properties and flood risk:
Results from the Broad-scale and Detailed field surveys

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Overview of the Landwise Broad-scale and Detailed Field Surveys

WP2 Field Survey Measurement Concepts

Measure properties

Broad-scale survey of 164 fields

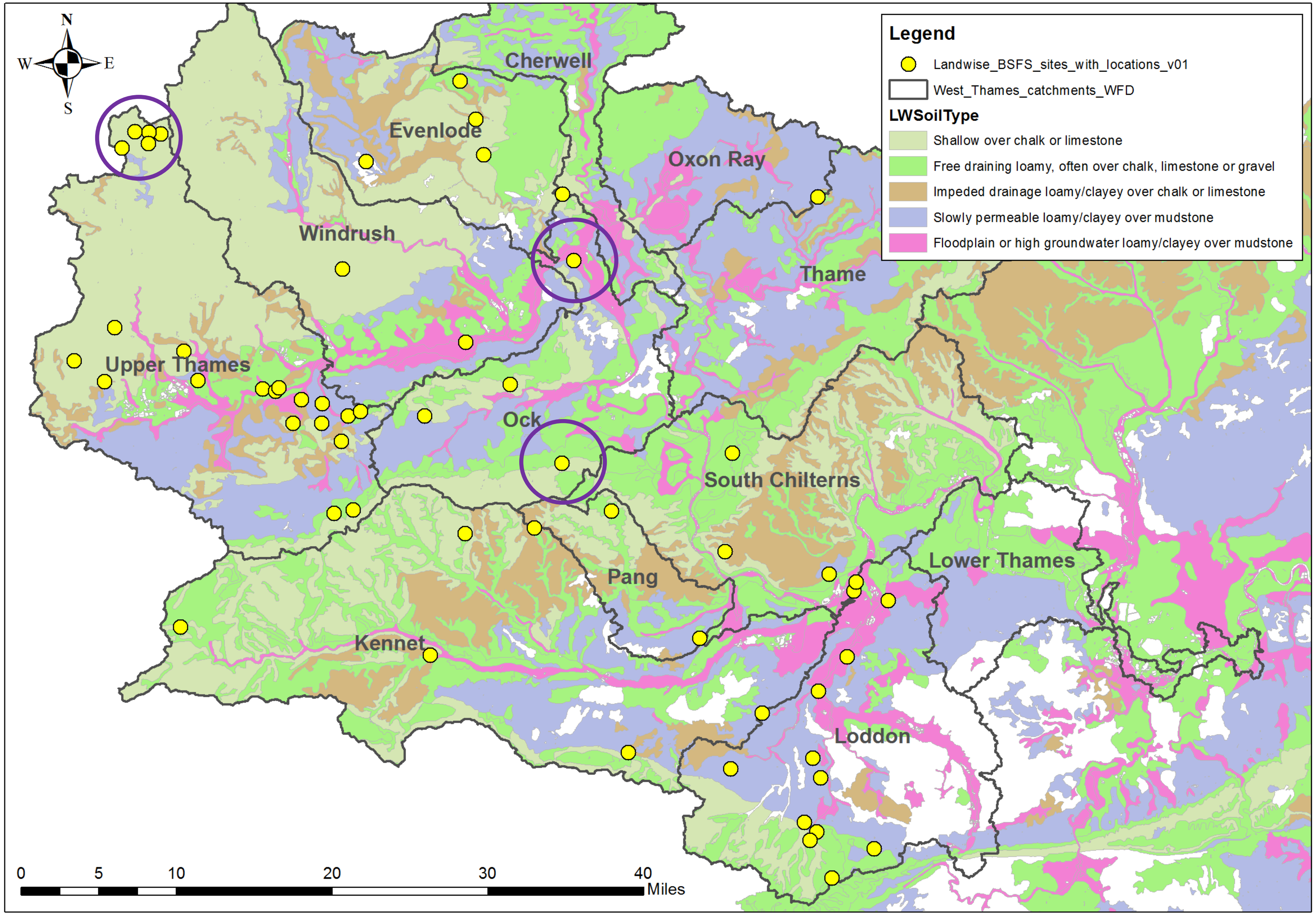
- Measure **properties of soil** that influence storage of water below ground: *bulk density (porosity), texture, structure, organic matter.*
- Focus on **soil surface** (top 50 mm)

Measure water

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

Survey locations – West Thames catchment



Broadscale field survey

- 164 fields sampled once from 48 farms over 2019-20 (1800 points)
- 4 different land uses over 5 generalised soil types

Detailed field survey

- 3 management comparisons over 7 fields
- Sampled in spring before and after harvest to capture change over one year (2021)

Field survey sampling

Broadscale Survey: 164 fields with 5 soil types and 4 land uses

Geology	LANDWISE Soil Type	Land use and management			
		Arable		Grassland (permanent, est. 5+ yr.)	Woodland (broadleaf, mature)
		Rotation with grass*	Rotation without grass		
Carbonate (Chalk, Limestone)	Shallow over chalk or limestone	8 + 6	9 + 1	8	8
	Free draining loamy [1]	9 + 1	8 + 1	8	8
	Impeded drainage loamy/clayey	4	9	8	8
Mudstone	Slowly permeable loamy/clayey	8	8	8	8 + 1
	Floodplain or high groundwater loamy/clayey	4	7	8	8

* incl. grass only rotation (e.g. dairy), not just grass as break crop

[1] sometimes also over gravel superficial deposits overlying mudstone

Detailed Survey

- 3 arable fields with herbal ley, rye & clover and no grass on shallow soils over limestone.
- Controlled and conventional traffic on medium soils over chalk.
- Broadleaf woodland compared to permanent grass on heavy soil over mudstone.

Field survey – example measurements

Broadscale Survey

Visual Estimation of Soil Structure.
Surface soil sample for analysis of VWC and BD, aggregate stability, OM, hand texture and laser particle size.

Detailed Survey

BD and OM at 5 depths to 1m
Soil saturated hydraulic conductivity at 2 depths
Surface infiltration rate
Soil and vegetation root depth

Results

Field observations - example

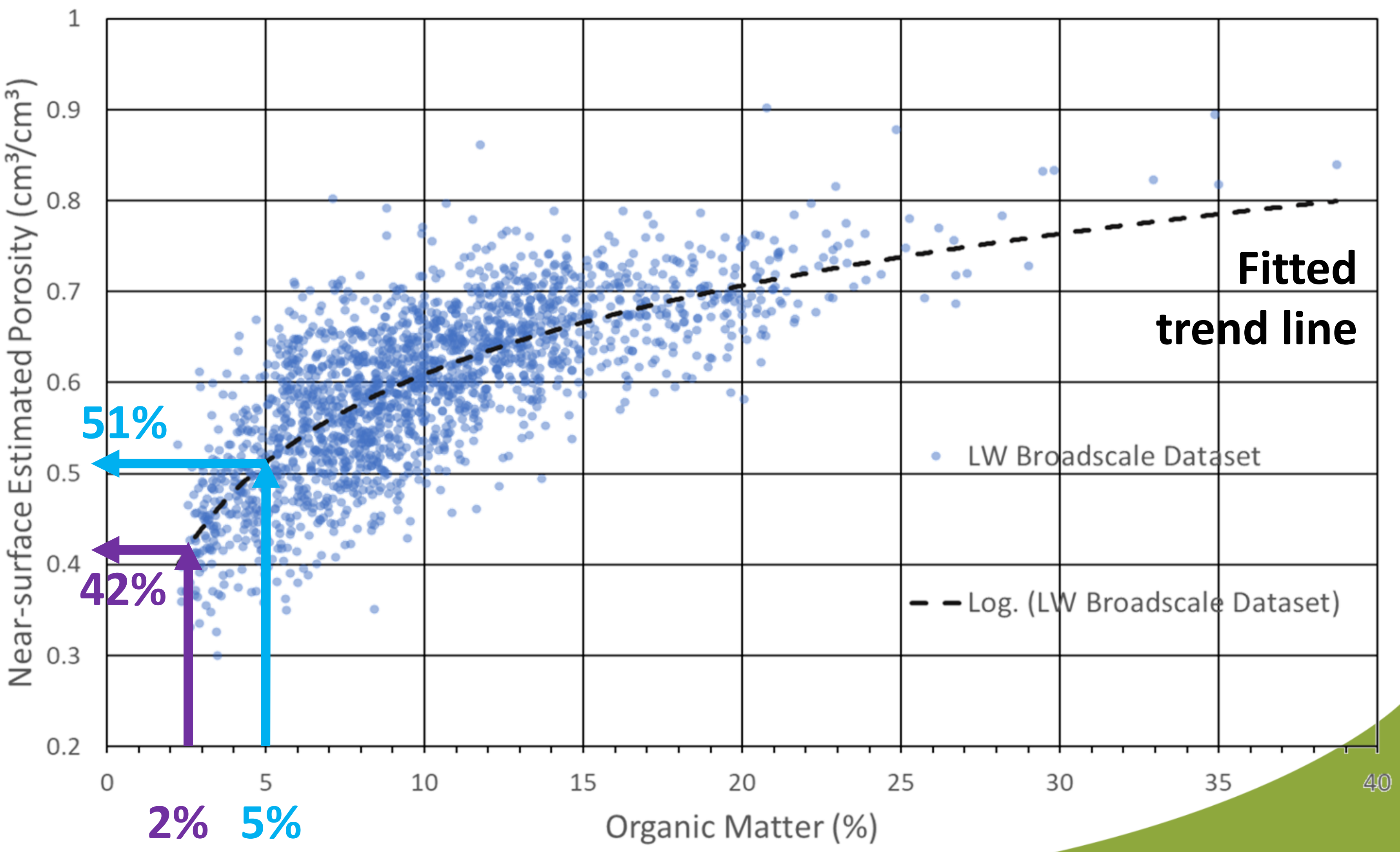
- Importance of soil surface condition - January 2020 (River Loddon catchment)
- Heavy clay soil
- Very near-surface saturated - water rapidly ponds and runs off, but deeper soil remains unsaturated (red arrow)

Broad-scale field survey – soil porosity

- Q: How much water can the soil hold (porosity)?
- Soil porosity estimated from bulk density data using:
  - soil mineral particle and organic matter typical densities (~2.65 and ~1.25 g/cm^3 respectively) and relative proportions
  - clay soils typically have higher porosity (lower BD) whilst sandy soils typically have lower porosity (higher BD)
  - related to soil particle shape and packing
- Q: How can we increase porosity (to reduce flood risk and provide more water for crops)?

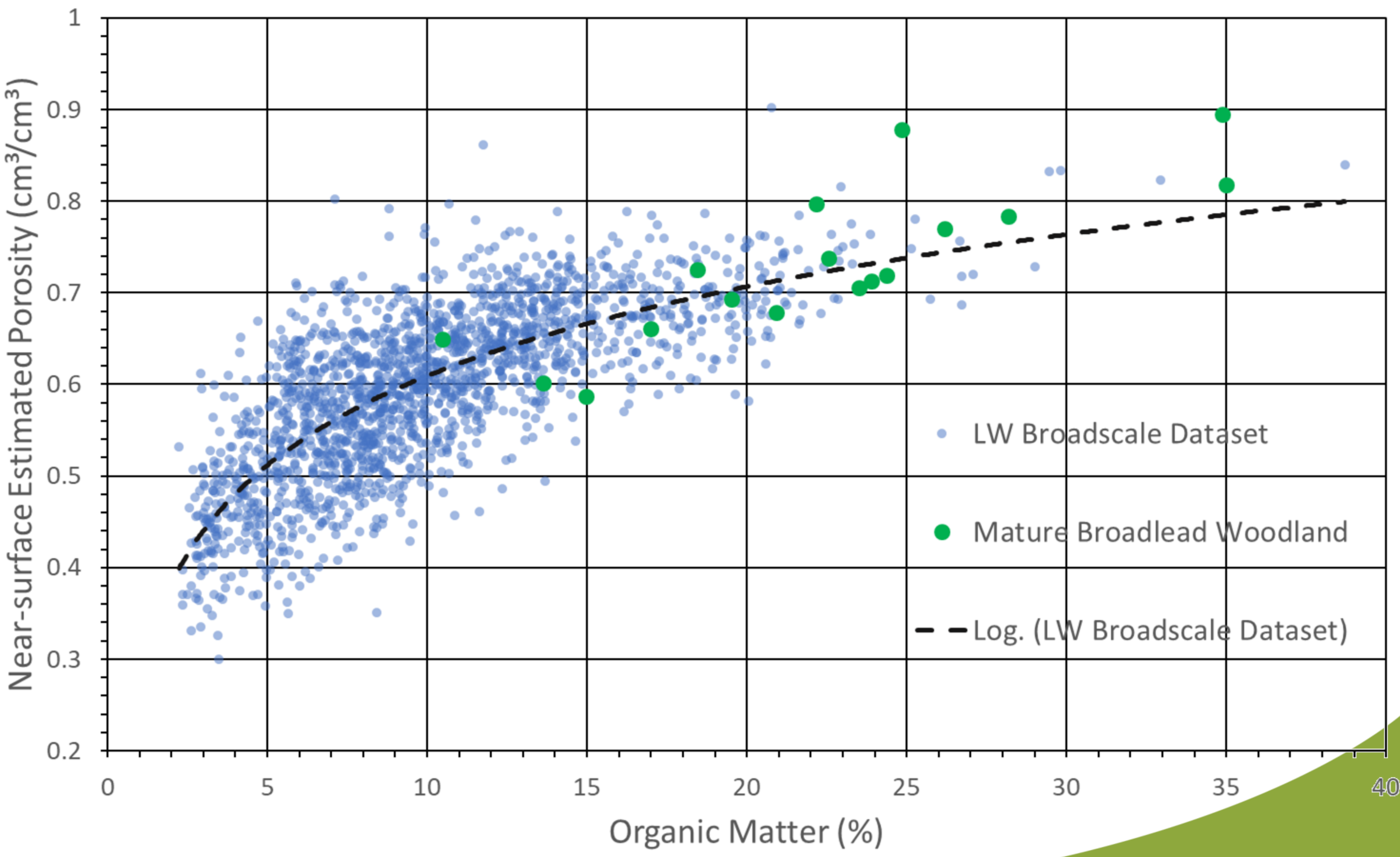
Broad-scale field survey – soil porosity & organic matter

- 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



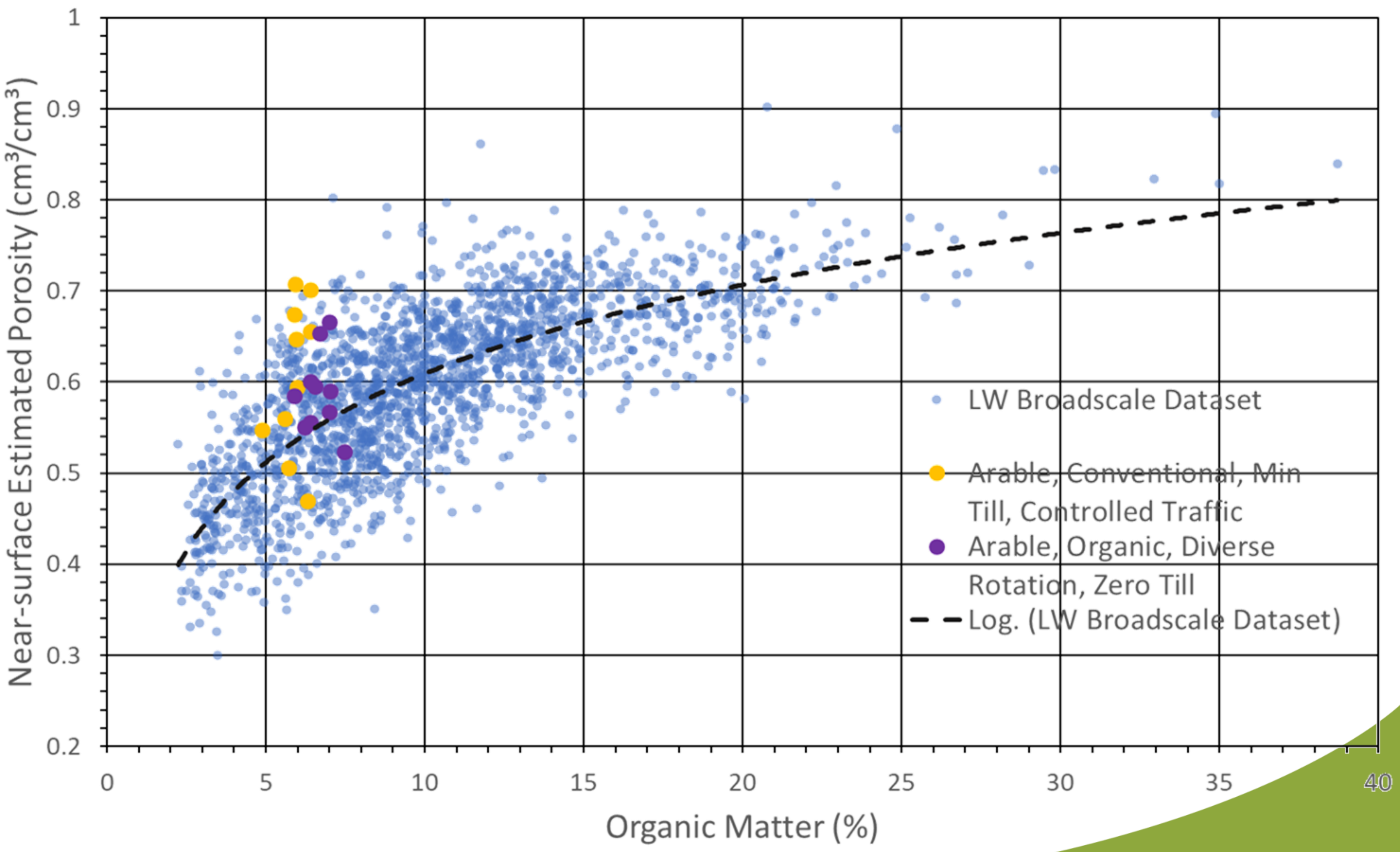
Broad-scale field survey – soil porosity & organic matter

- Land use and management practices can have a significant impact on soil porosity
- Mature broadleaf woodland results in high soil porosity
- Example points show typical woodland conditions over a range of soil types



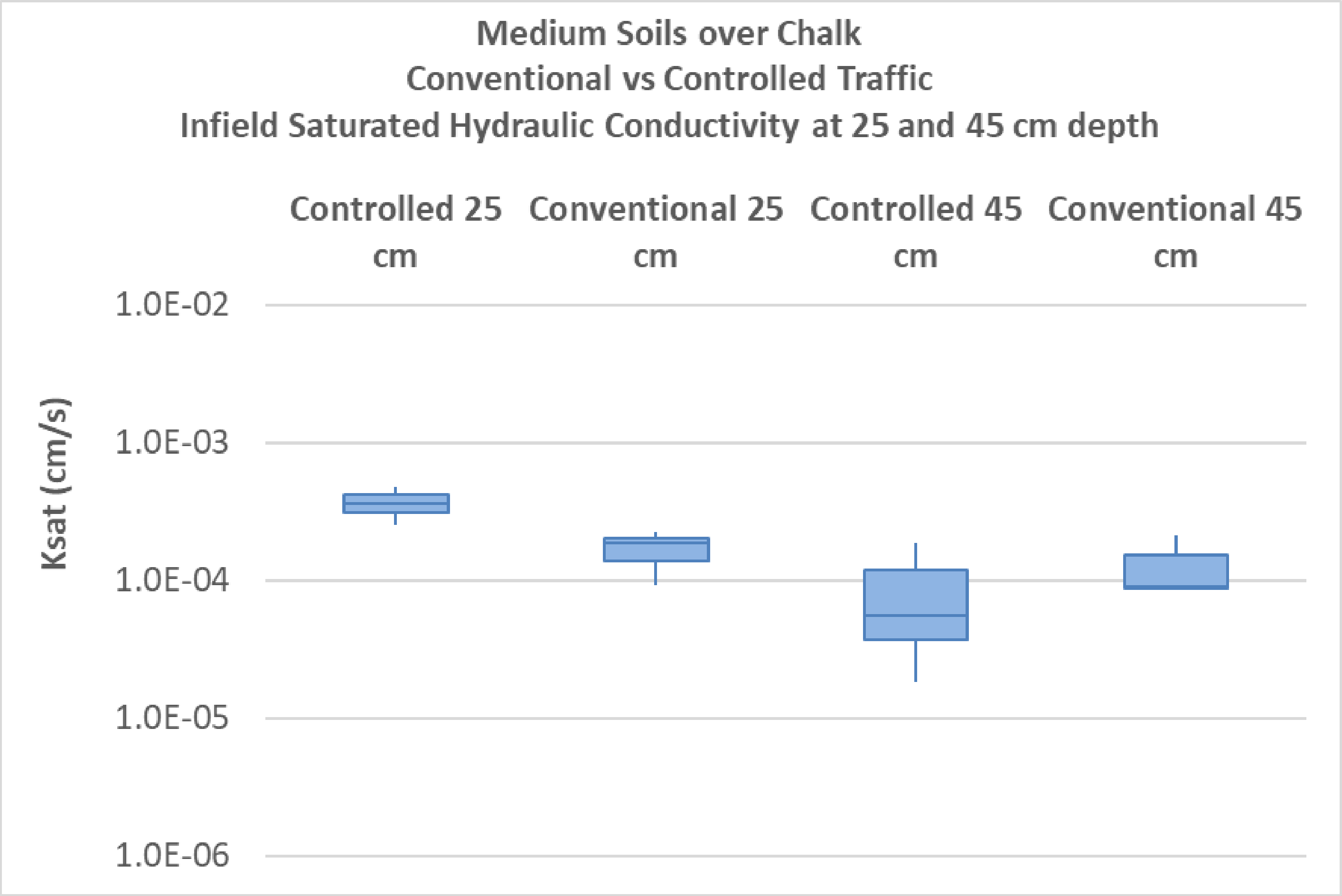
Broad-scale field survey – soil porosity & organic matter

- Land use and management practices can have a significant impact on soil porosity
- Innovative conventional and organic farming practices can result in high soil porosity
- Example points represent general infield and trafficked field conditions



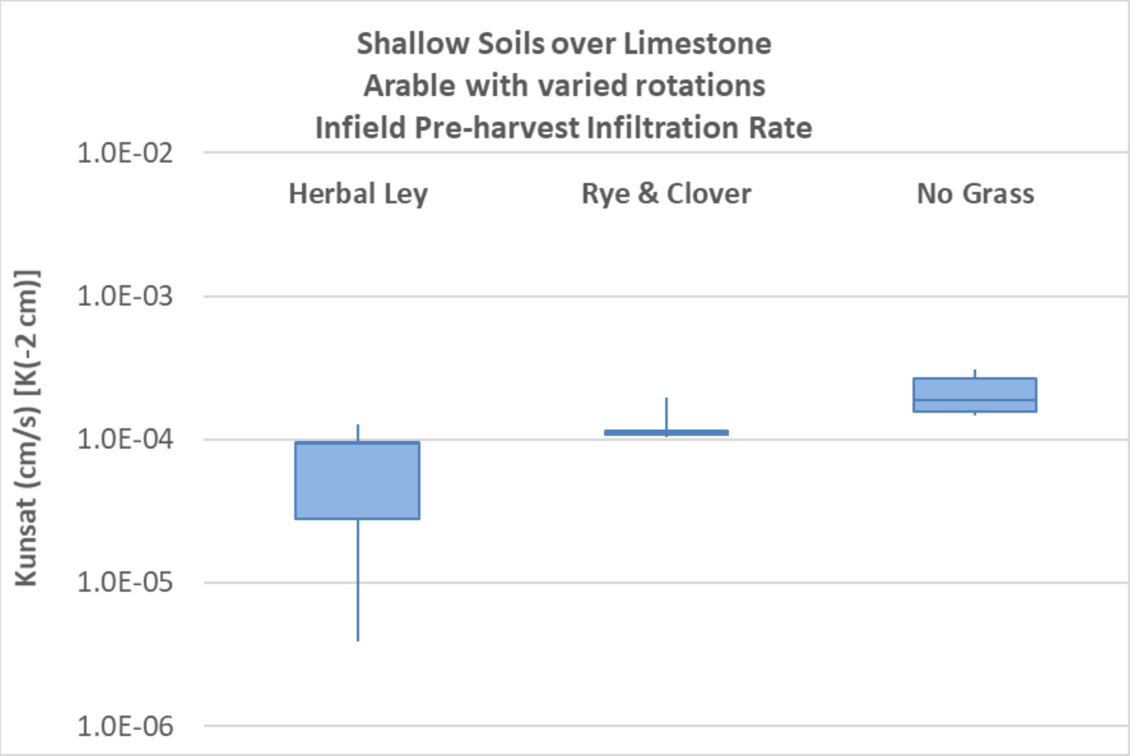
Detailed field survey - soil water: controlled vs conventional

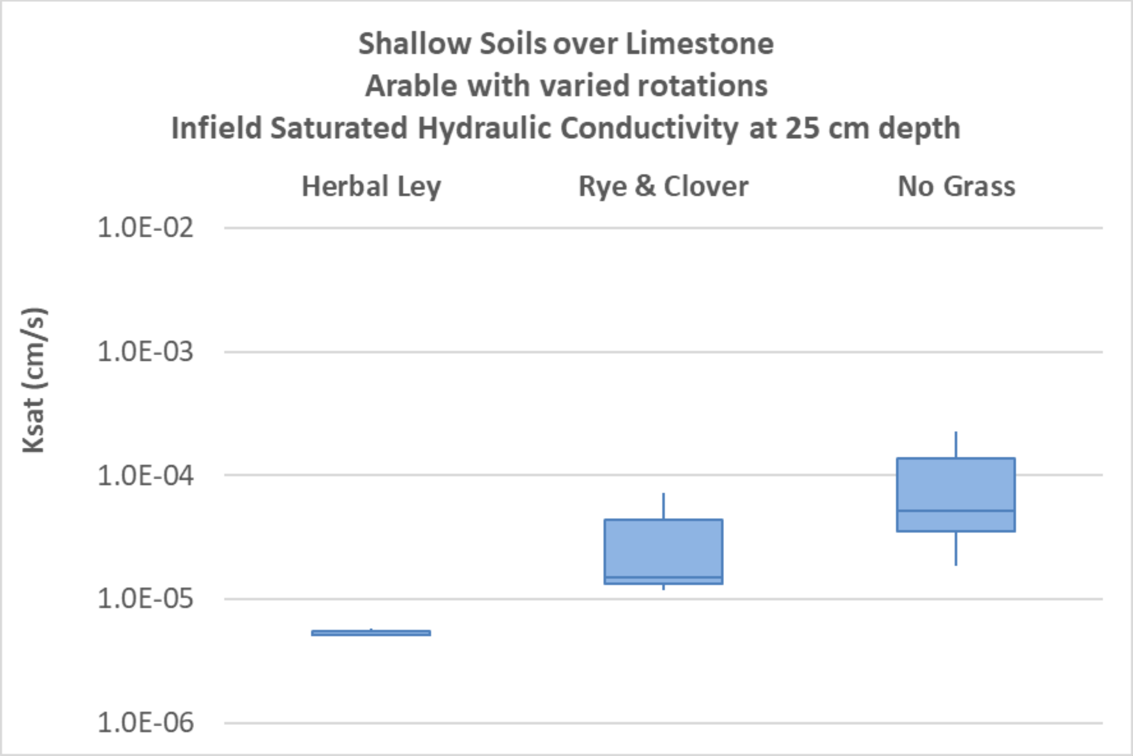
- Infield Ksat greater at 25 cm soil depth under controlled traffic with min till, compared to conventional management practices
- Higher Ksat will increase infiltration into, and percolation through soil, reducing surface runoff and associated flood risk
- Ksat decreases at 45 cm depth for both controlled and conventional management (increased consolidation and higher bulk density at depth)



Detailed field survey – soil water: varied arable rotations

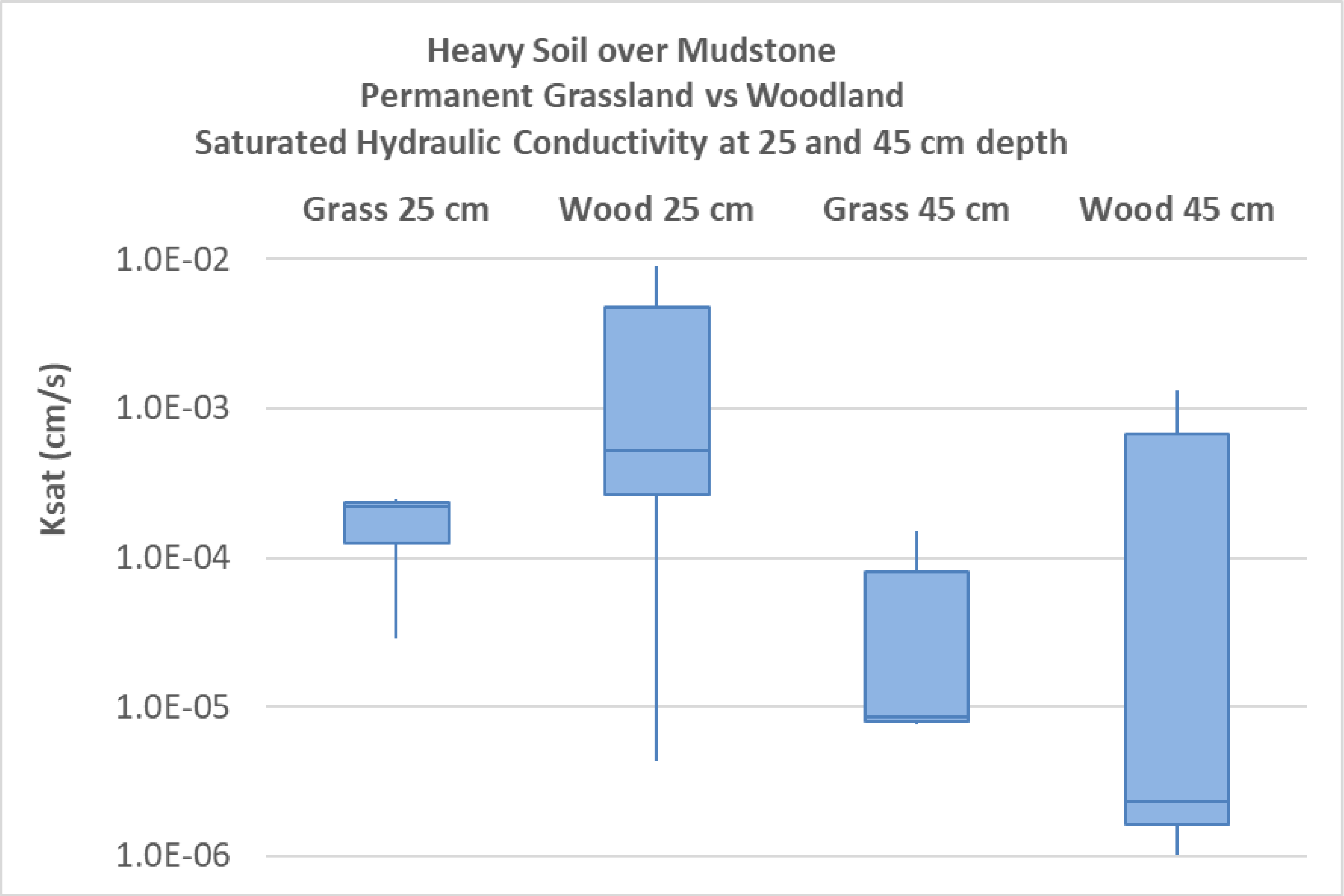
- Unexpected relationship shown by both Ksat and Kunsat.
- Highest infiltration and Ksat with no grass in rotation, decreasing with more diverse grass rotations (all in W. Wheat at time of sampling)
- Other influencing factors & management practices to investigate e.g. grazing on grass rotations and possible compaction.





Detailed field survey – soil water: grassland vs woodland

- Ksat higher in woodland relative to grassland.
- Higher Ksat will increase infiltration into, and percolation through soil, reducing surface runoff and associated flood risk
- As in arable fields, lower Ksat at 45 cm depth for both grassland and woodland.
- Greater variability in woodland soil structure and resultant Ksat.



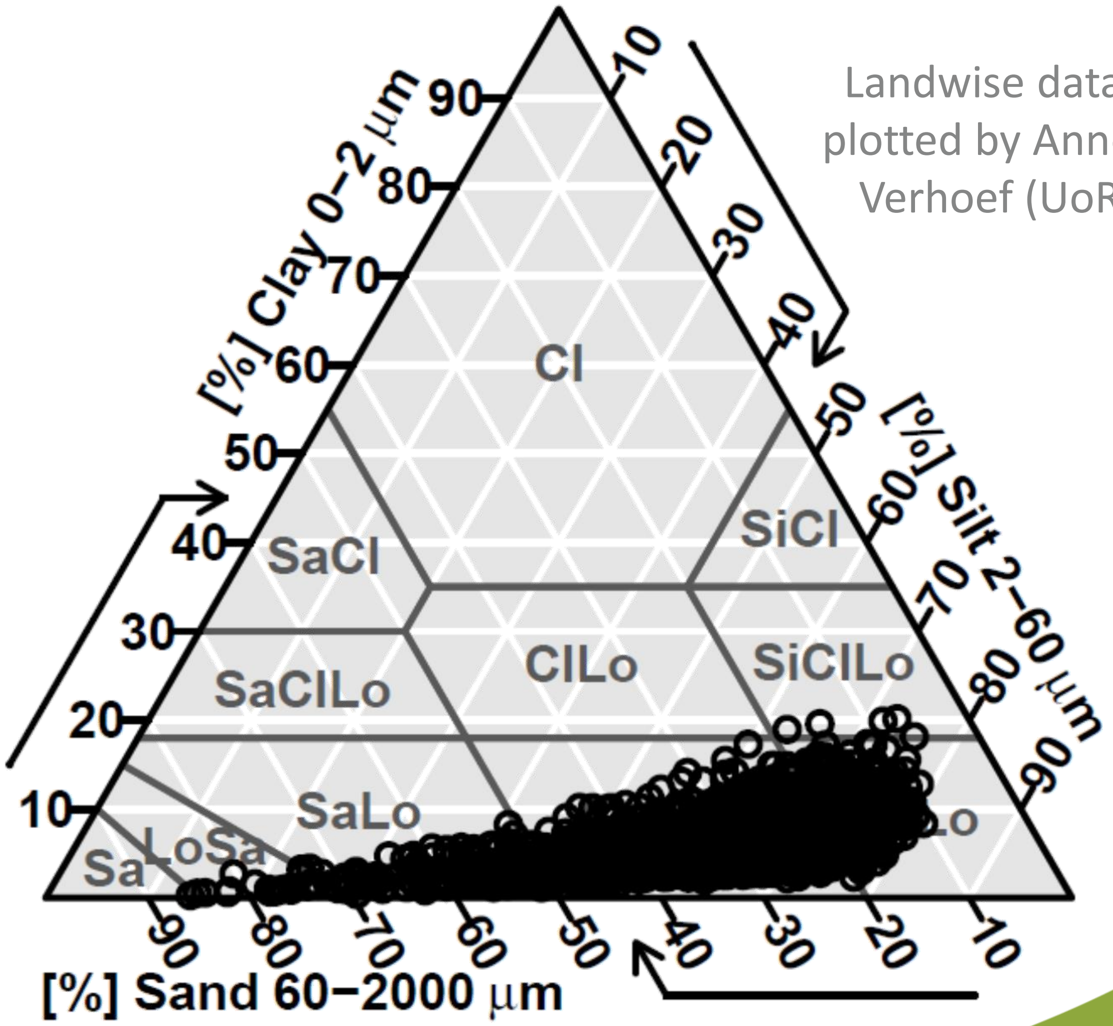
Summary of findings so far

- Management of near-surface soil properties and preferential flow pathways is important so that deeper soil water storage is available and accessible.
- Land use and management practices can significantly enhance soil physical and hydrological/hydraulic properties and flood mitigation potential.
- Increasing organic matter content increases soil porosity, creating more soil water storage and potential to mitigate flooding.
- Fields with 'low' starting organic matter content can greatly improve soil porosity therefore soil water storage with relatively modest organic matter increases.
- Organic additions are not the only way to improve soil structure, innovative management practices (e.g. controlled traffic and min till) also improve soil structure, saturated hydraulic conductivity and therefore NFM potential.
- Mature woodland has the highest organic matter content, soil porosity, saturated hydraulic conductivity and NFM potential relative to arable and grass land use.
- Effects of arable rotations and inclusion of grass in rotations are being investigated.

Thank you!

Broad-scale field survey – soil texture analysis

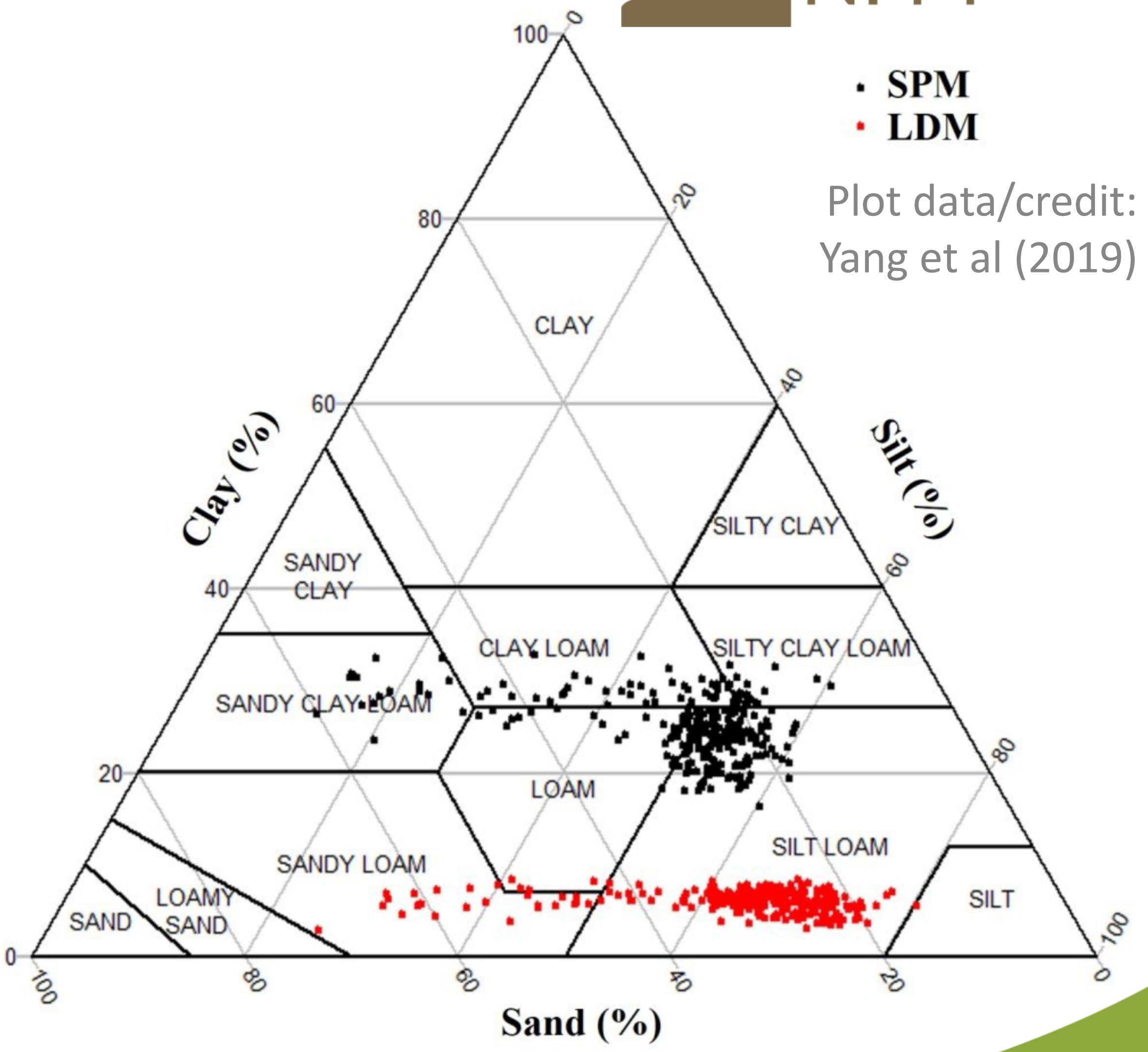
- Soil particle size distribution measured with laser particle sizer (Mastersizer 2000)
  - 1800 samples over a range of soil types across West Thames catchment
  - Plotted on SSEW texture triangle →
  - Q: Where has all the clay gone?! (max ~ 20%)
- Re-checked lab protocol incl. MS2000 analysis parameters ✓
- UoR comparison of selected samples against soil texture field scanner (this method estimates higher clay!)
- NB: Texture triangle defined from measurements using 'traditional' sieve-pipette/hydrometer methods



Landwise data, plotted by Anne Verhoef (UoR)

Broad-scale field survey – soil texture analysis

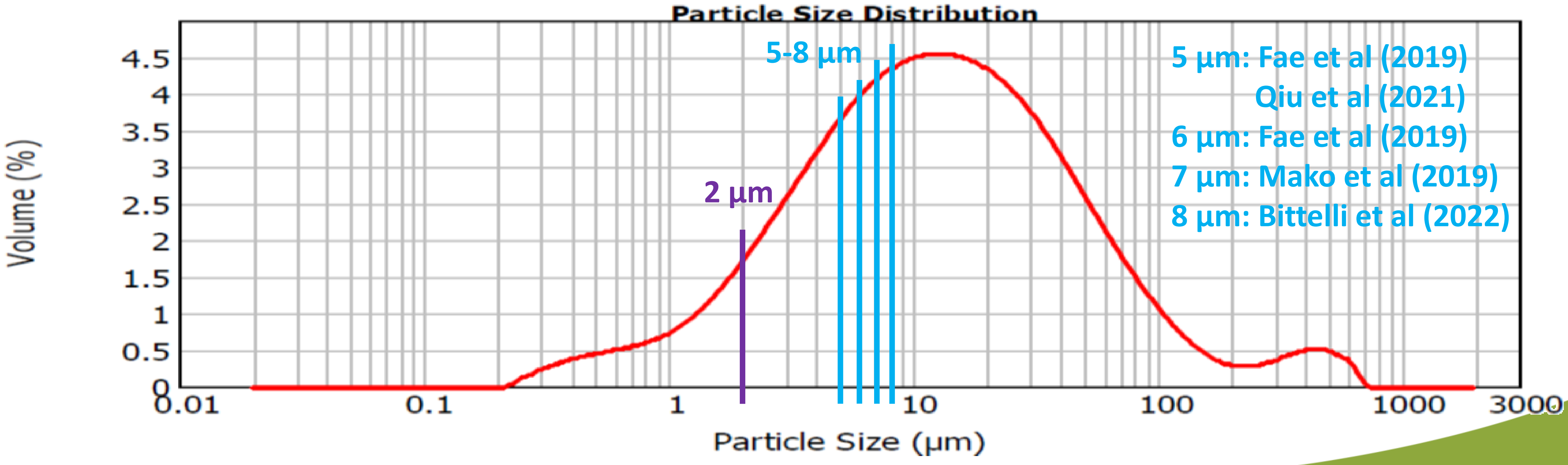
- Literature review
  - Laser Diffraction Method (LDM) in good agreement with Digital Imaging – taken as reference – Bittelli et al (2022)
  - Scanning Electron Microscopy shows 'traditional' methods (sieve-pipette: SPM) wrongly include some silt particles in 'clay' fraction – Yang et al (2019) – known issues related to assumed particle shape and density
  - LDM likely effective for soil particle size measurements…
  - However soil texture databases, triangles and pedotransfer functions (used in modelling) all currently based on traditional SPM…
    Q: How to make LDM data comparable?



Plot data/credit: Yang et al (2019)

Broad-scale field survey – soil texture analysis

- LDM (volumetric %) to SPM (gravimetric %) soil texture conversion equations available, e.g. Yang et al (2015)…
  - However unlikely to be generally applicable, probably site/soil specific (e.g. Konert & Vandenberghe, 1997; Eshel et al, 2004; Pieri et al, 2006; Yang et al, 2019)
- Recent research into redefining the clay-silt cutoff boundary for soil texture determined using LDM (compared to traditional 2 µm cutoff):



Example Landwise LDM data

Broad-scale field survey – soil texture analysis

- Reprocessing Landwise LDM soil particle size distribution data – example testing the potential solution:

Clay-Silt cutoff	Sand (%)	Silt (%)	Clay (%)
2 µm (original data)	11	80	9
7 µm (potential solution)	11	55	34

- Clay (and Silt) percentages seem more reasonable – it seems possible to reprocess LDM data to be comparable with traditional soil texture methods
- Work in progress – reprocessing 1800 data points…!

Comparing different ways to classify or talk about soils

SSEW Higher Categories	Landwise Aggregated Soilscapes	SoilScapes	RB209	Think Soils	Generalised Geology
Lithomorphic	Brash: Shallow chalk or limestone	3	Shallow soils	*Chalk and limestone soils*	Carbonate
Brown	Loam: Free draining loamy	5, 6, 7	Medium soils	Medium soils/ *Chalk and limestone soils*	Carbonate
Pelosol/Argillic brown earths	Clay over chalk: Impeded drainage loamy/clayey	8, 9	*Medium soils* *OR Deep clay/deep silty soils*	Medium soils	Carbonate
Surface Water Gley	Deep clay: Slowly permeable loamy/clayey	18	Deep clay/deep silty soils	*Heavy soils*	Mudstone
Ground Water Gley	Floodplain: Floodplain or high groundwater loamy/clayey	20,22	Deep clay/deep silty soils	*Heavy soils*	Mudstone