LANDWISE: Impacts of land use and management on soil properties and flood risk

FIELD SURVEY

UK Centre for Ecology & Hydrology, University of Reading, British Geological Survey, Forest Research & Partners

Emily Trill, James Blake, Pete Scarlett, John Robotham, Alex O'Brien and Gareth Old
UKCEH

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Introduction

- Project aim: Evaluate the impact of land use/management related natural flood management measures for lowland catchments
- Broad-scale field survey - overview and preliminary results
- Detailed field survey - plans

Broadscale survey vs Detailed survey

- Broad scale field survey (completed)
  - 154 fields sampled once from 45+ farms over 2019-20
  - 4 different land uses: Arable with grass, Arable without grass, permanent grass and broadleaf woodland
  - 5 generalised soil types that compare to 3 soil types using RB209 classification: heavy soils, medium soils and shallow soils
  - Measures soil properties that affect infiltration but are less affected by rain (or not) on day of sampling – bulk density, texture, structure, organic matter.
- Detailed field survey (underway)
  - 3 locations/management comparisons with 2-6 fields at each location
  - Fields sampled multiple times over one year to capture change over time (20-21)
  - More measurements made with soil depth and spatial coverage
  - Measuring properties that change over time – infiltration, soil water, surface roughness using invasive field measurement and non invasive samplers and drones

Broad-scale Field Survey: Overview

Broad-scale field survey

- Survey aim: Quantify land use/management impact on near-surface soil properties which affect water infiltration/storage
- Soil bulk density (porosity), organic matter, texture, structure, volumetric water content, aggregate stability
- Vegetation type, height and cover
- Co-produced with Farm Advisors and Landwise Working Group

EA (2007)
Think Soils Manual

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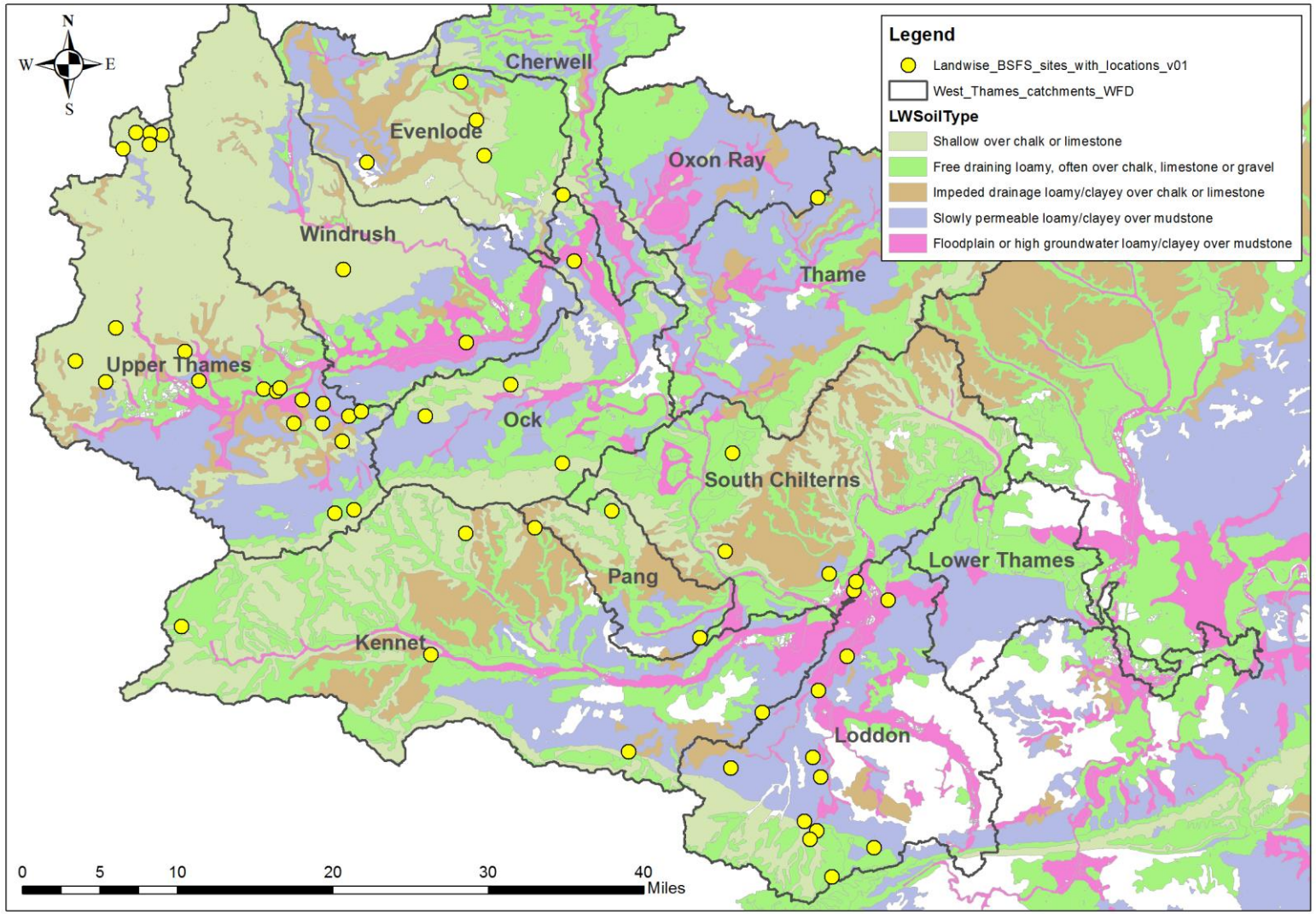
Broad-scale field survey – W. Thames catchment



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Broad-scale field survey – sampling

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	6	9	8	8
	Free draining loamy [1]	6	8	8	8
	Impeded drainage loamy/clayey	2	9	7	8
Mudstone	Slowly permeable loamy/clayey	8	7	8	8
	Floodplain or high groundwater loamy/clayey	4	7	8	7

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

[1] sometimes also over gravel superficial deposits overlying mudstone

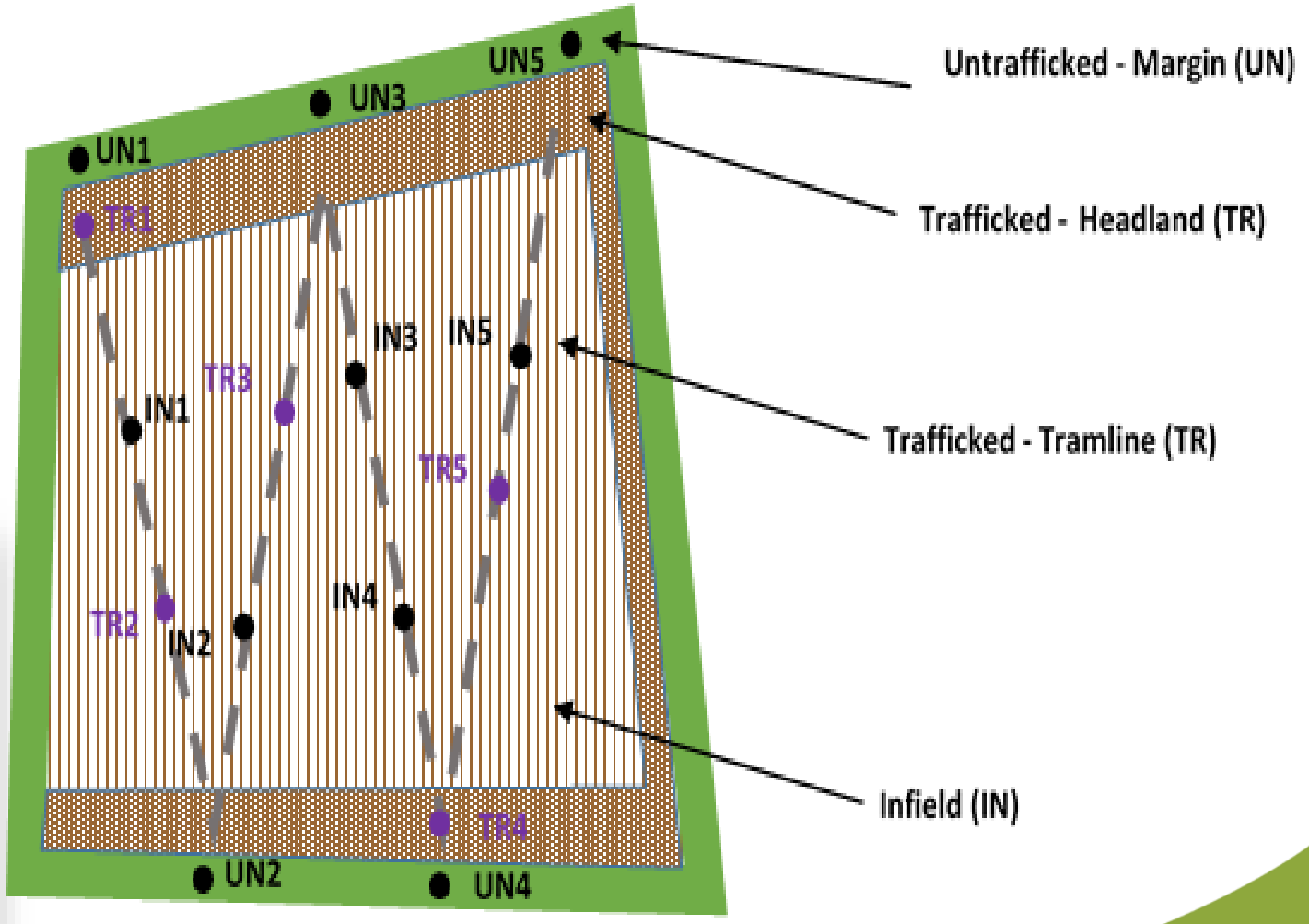
Broad-scale field survey – methodology

LANDWISE NFM

Arable sampling - example

15 sample locations per field:
5 infield
5 trafficked *(cropped headland or tramlines)*
5 untrafficked margin
(uncultivated/uncropped rough margin, avoid within 1 m of tree/hedge stems and animal burrows)

3 VESS:
one sampling location from each of infield, trafficked and untrafficked



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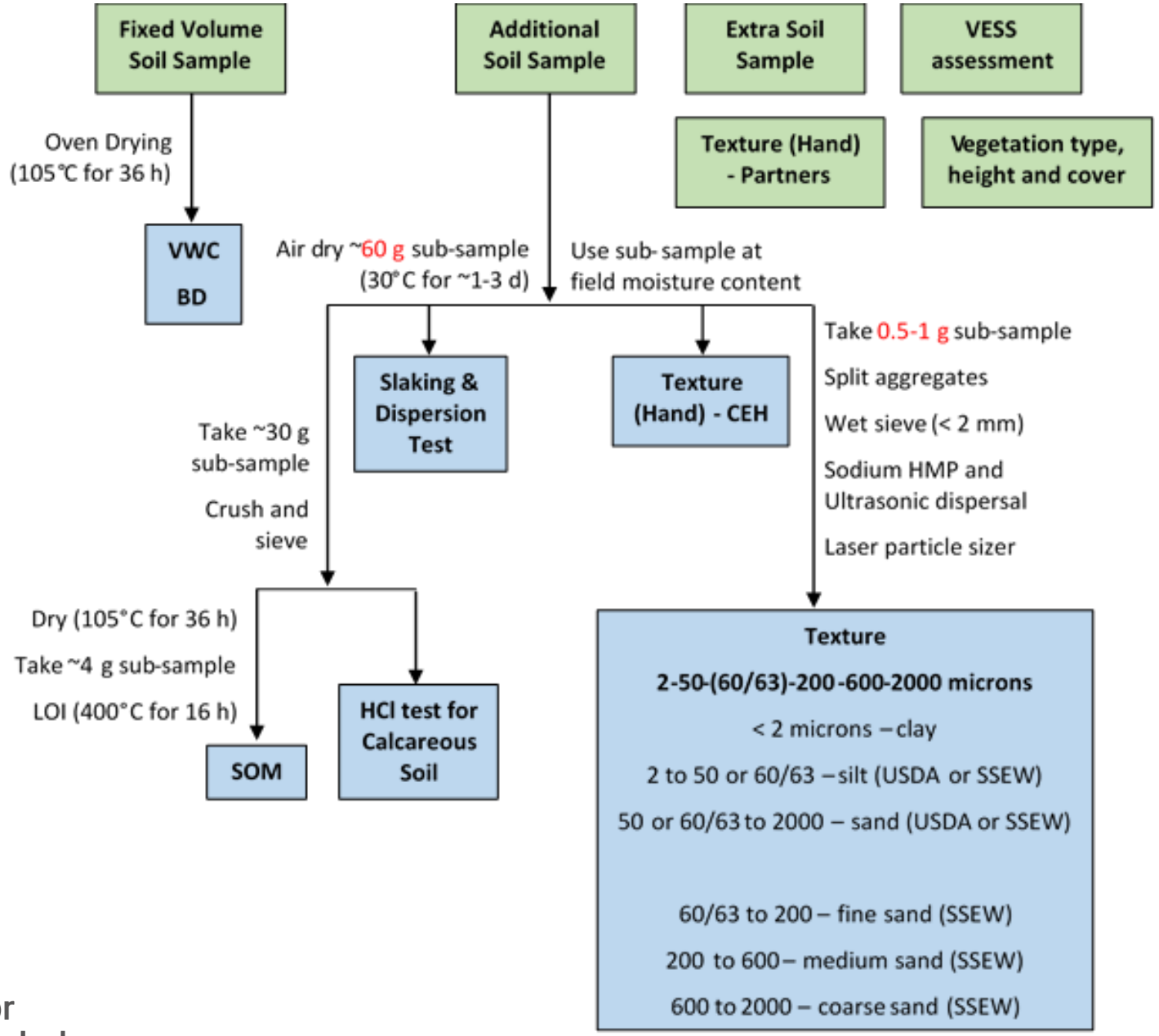
Field

Lab



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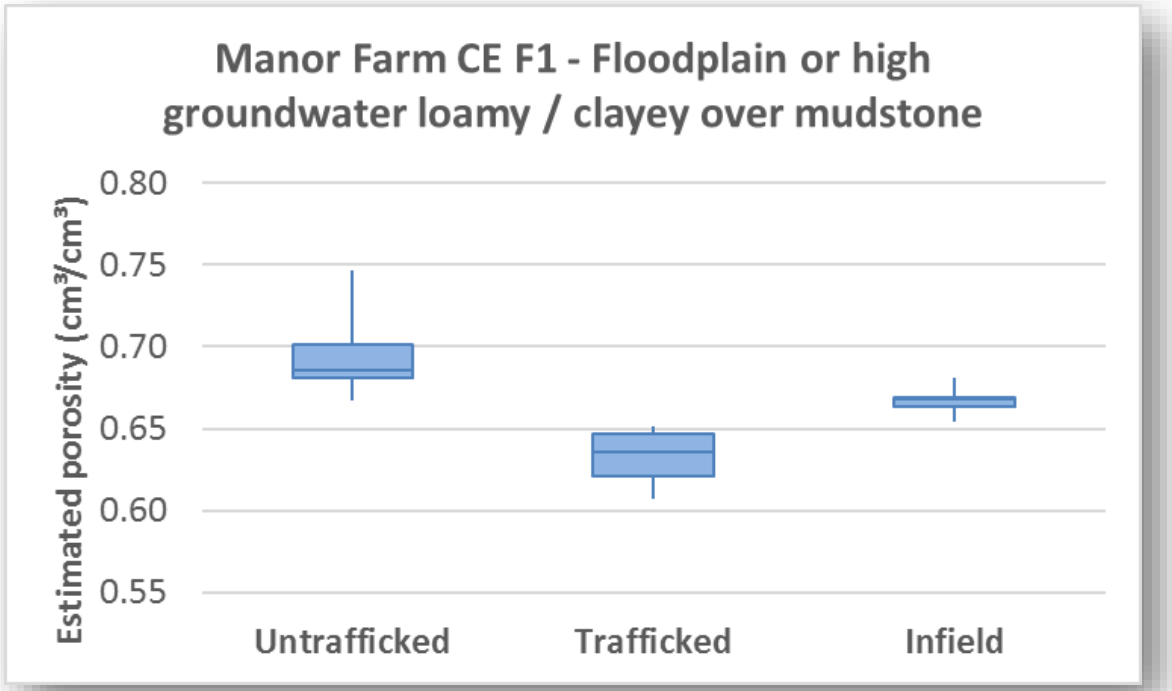
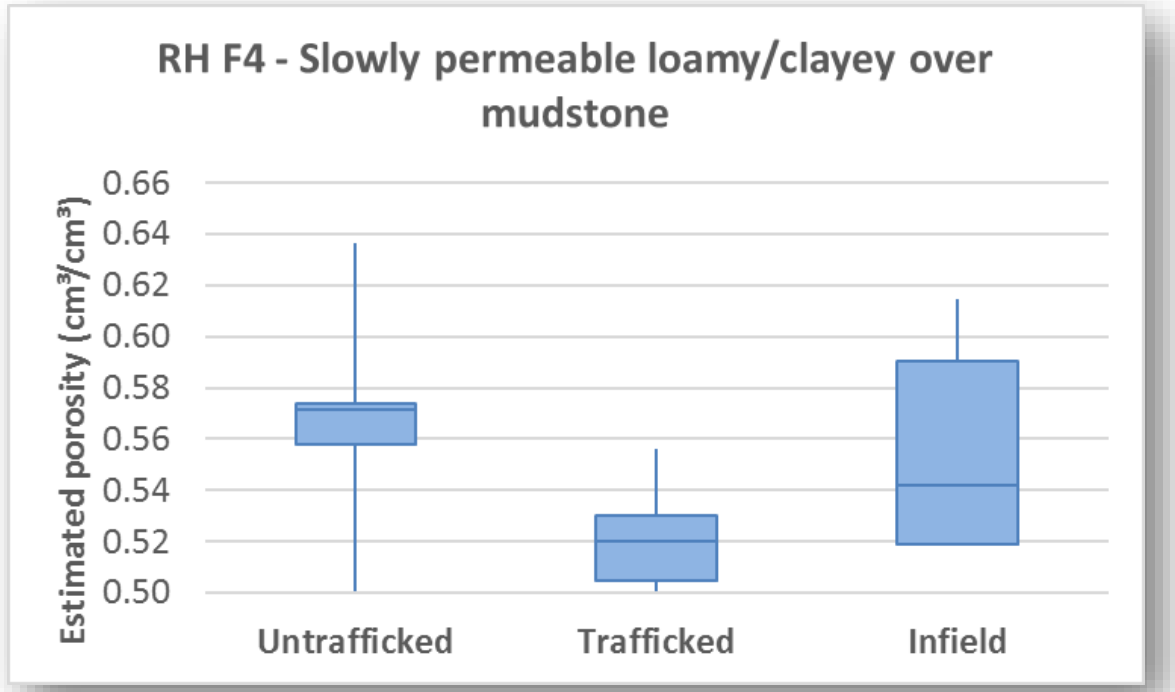
Broad-scale Field Survey:
Preliminary Results and Field Observations

Broad-scale field survey: preliminary results



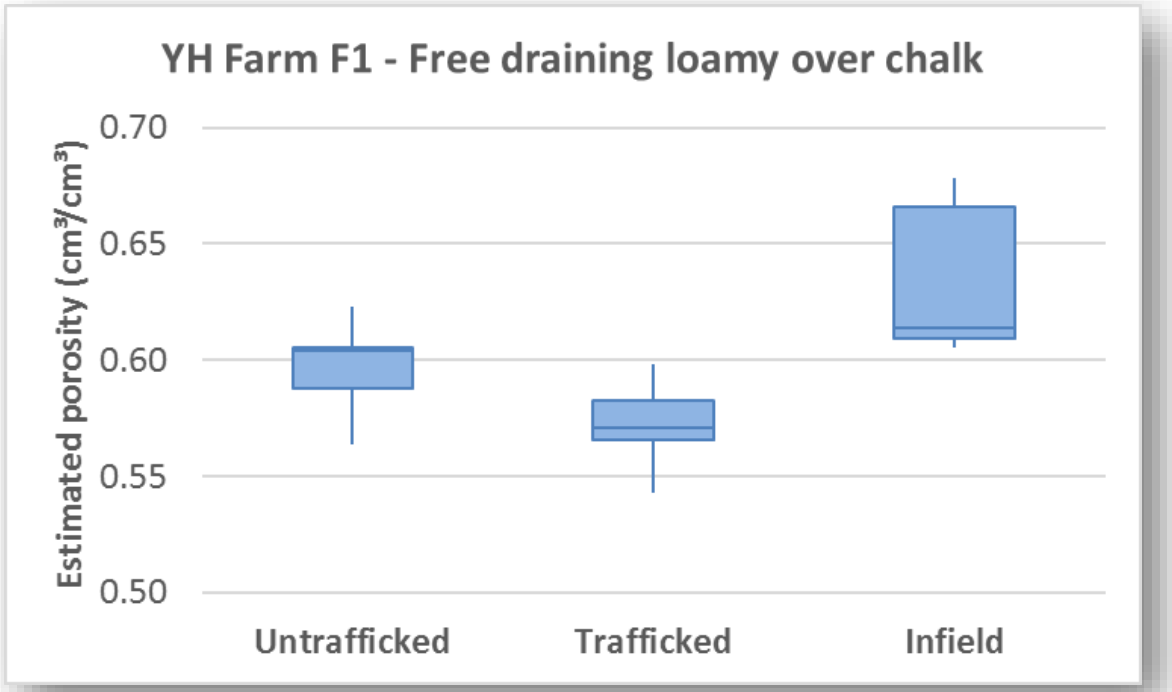
- Conventional arable without grass in rotation, min till
  - infield areas have higher porosity than trafficked, but less than untrafficked margin

Broad-scale field survey: preliminary results



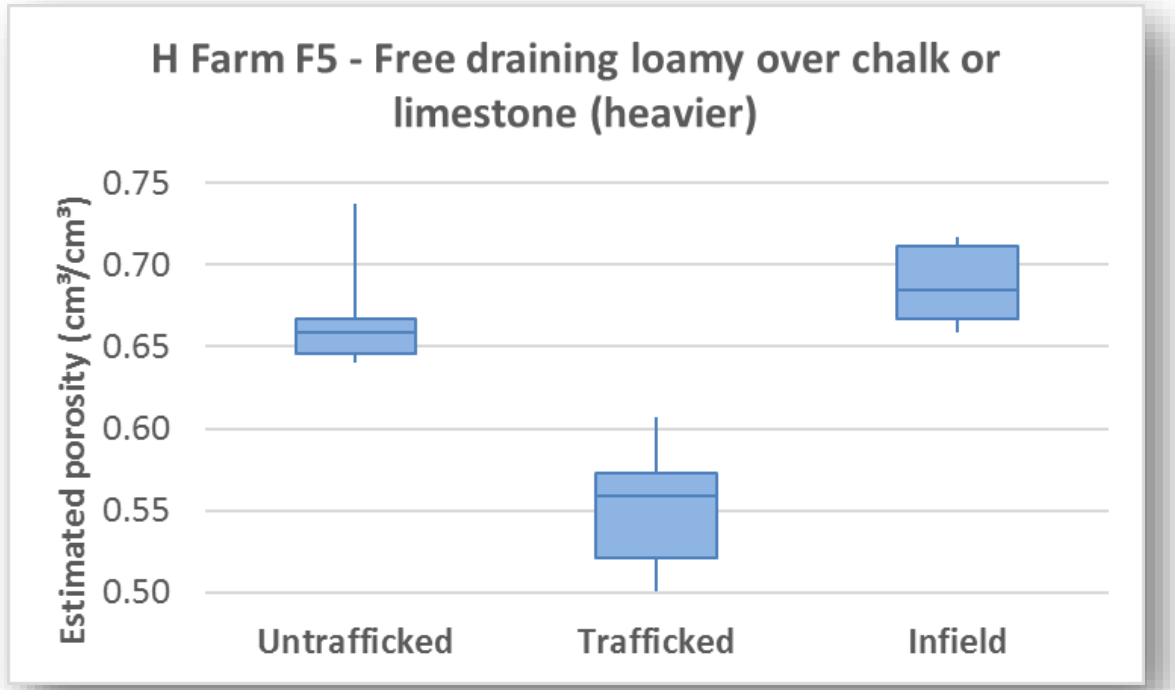
- Organic arable with grass ley in rotation, ploughed, disc & harrow, paddock grazed
  - some infield areas have similar porosity to untrafficked margin

Broad-scale field survey: preliminary results



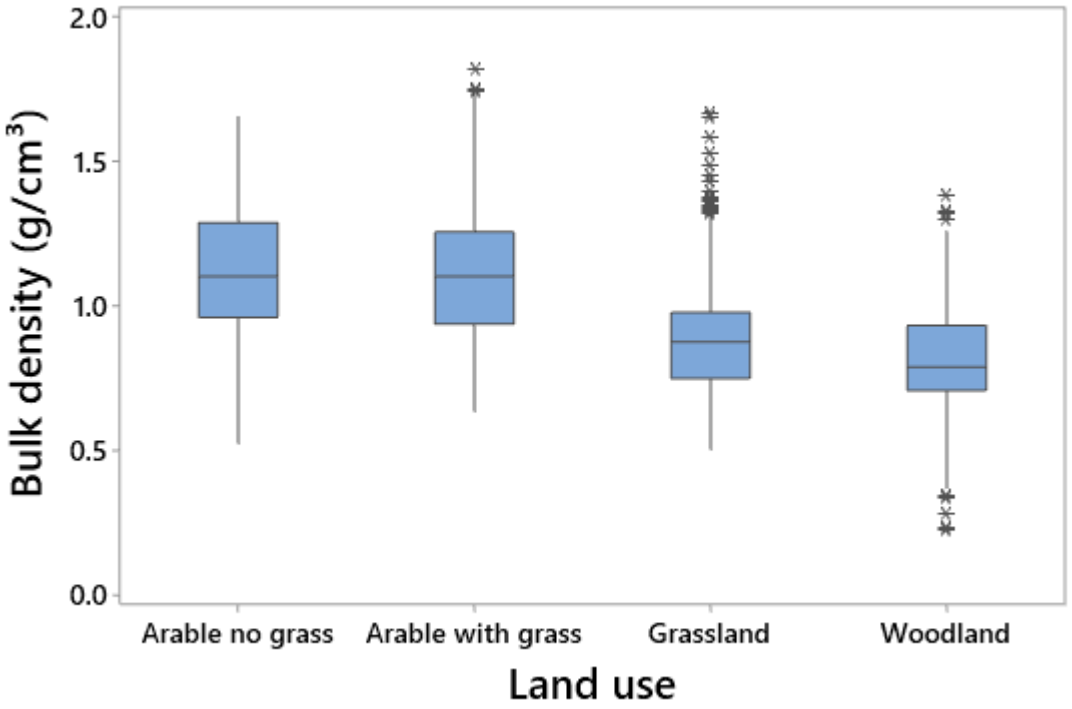
- Organic arable with diverse ley grassland in rotation, zero tillage, limited/sensitive trafficking
  - infield areas have higher porosity than both trafficked and untrafficked margin

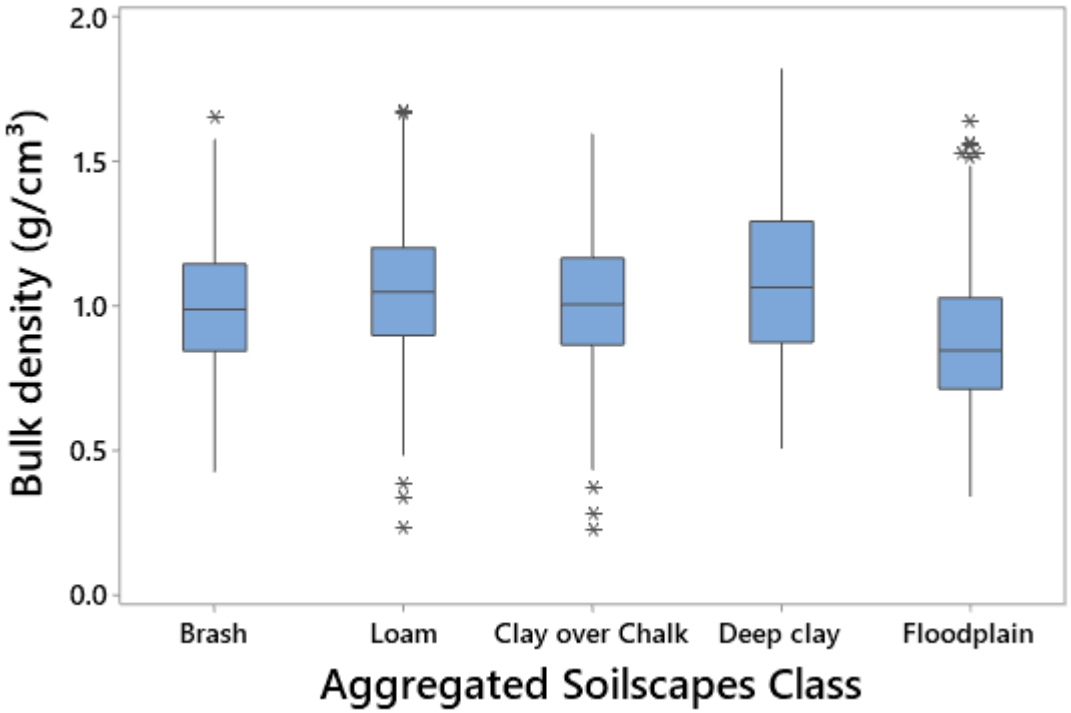
Broad-scale field survey – preliminary results



- Conventional arable without grass in rotation, cover crops, min till, direct drill, controlled traffic
  - infield areas have higher porosity than both trafficked and untrafficked margin

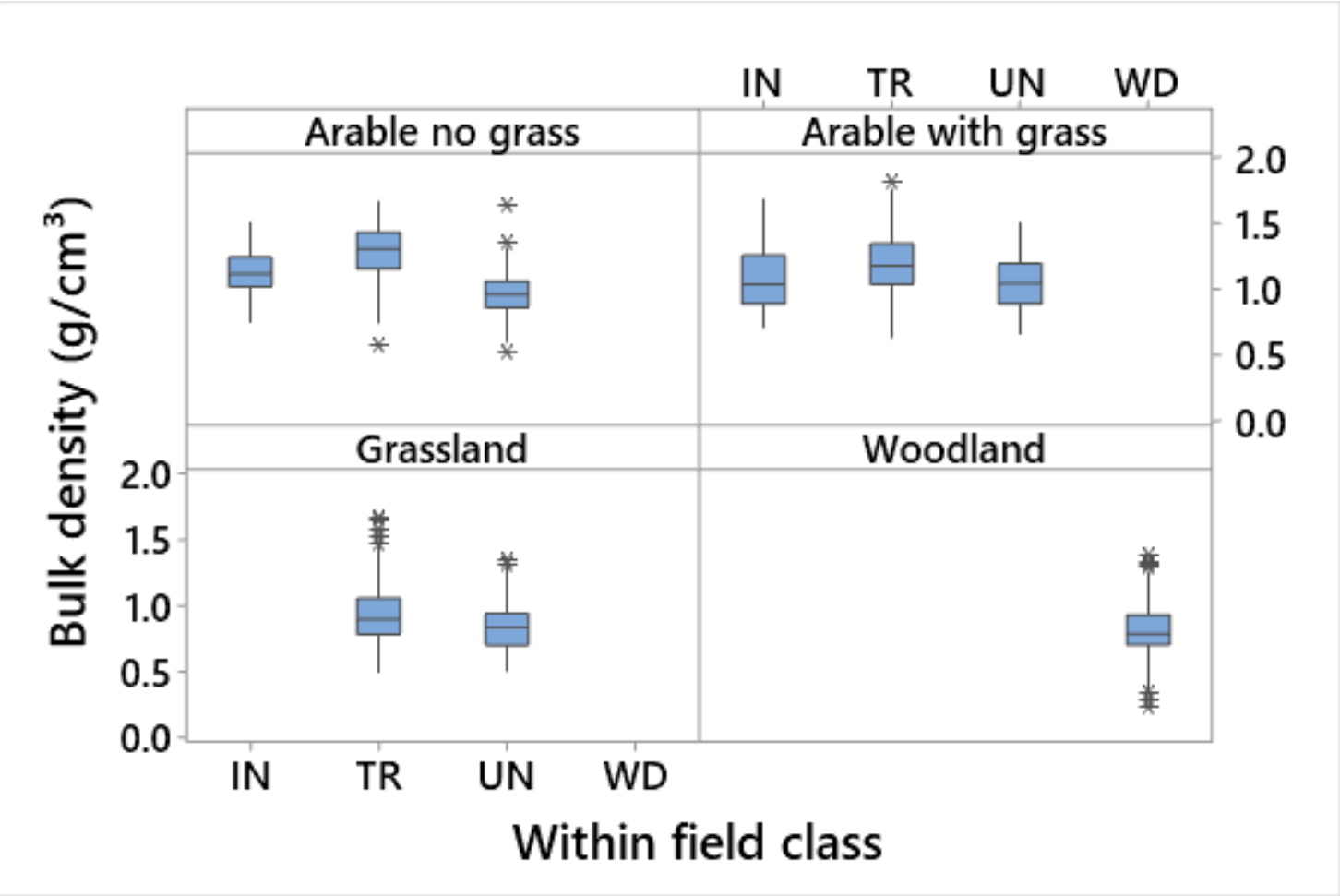
Main Effects: Land Use and Soil Class





Mixed Effect Model of Bulk Density
Fixed Effects: Land use, Soil, Land use x Soil, within field(Land Use)
Random Effects: Farm
Co-variate: Log(Organic Matter)
Adj R2 76.8%, models terms significant p<0.000

Main Effects: Within field variation by Land Use

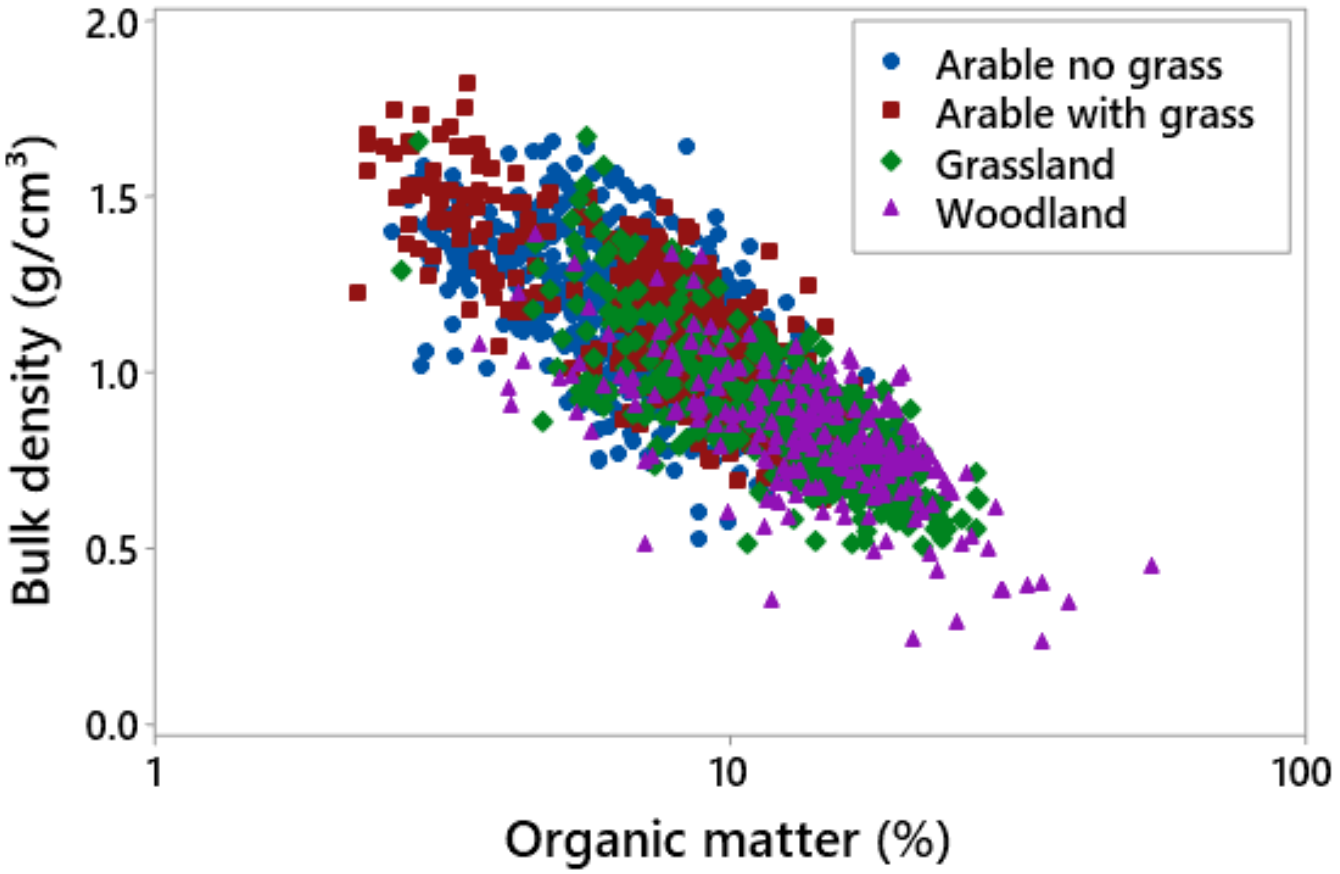


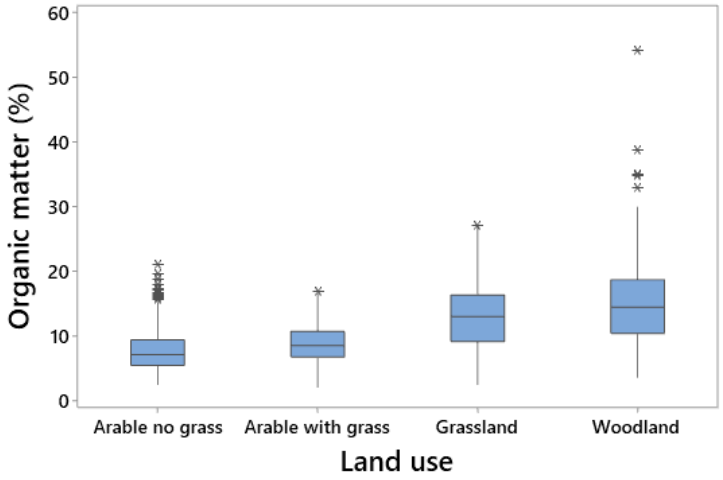
In both arable classes, the trafficked area has significantly higher bulk density than the infield or untrafficked margin.

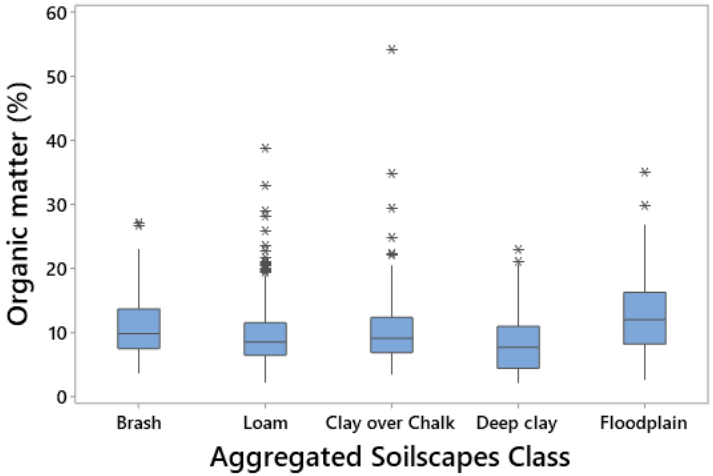
In grassland, trafficked areas have significantly higher bulk density than untrafficked areas.

Within Field Class
IN – Main field
TR – Trafficked
UN – Untrafficked margin
WD - Woodland

Co-Variate: Organic Matter and Bulk Density







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Comparing different soil classification systems

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

Broad-scale field survey – field observations

- Tramlines
  - compaction, runoff pathways
  - deeper soil unsaturated

Broad-scale field survey – field observations

- Heavy clay soil
  - water moving quickly downslope through soil macropore

Broad-scale field survey – field observations

- Heavy clay soil
  - near-surface saturated – water rapidly ponds and runs off
  - deeper soil unsaturated

Broad-scale field survey – field observations

- Silty loam soil
  - evidence of surface runoff down tramlines

Broad-scale field survey – field observations

- Floodplain woodland
  - slowing flood flows – moving across meander
  - natural woody debris dams, slowing surface runoff to main channel

Broad-scale field survey – summary

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- Interesting results so far…
- Importance of near-surface soil properties and preferential flow pathways
- Significant effects of land use and management on soil bulk density
- The effect of land use is greater than soil type, though both significant
- Trafficked areas have significantly higher bulk density than the infield or untrafficked margins
- Woodland porosity and organic matter significantly higher on same soil type
- Good correlation between soil organic matter and bulk density
- Effect of organic matter on bulk density stronger than soil type – crucial as land use and management can affect organic matter content but not texture.
- Need to explore soil texture and details of different management systems within our dataset – from conventional to conservation and organic agriculture.

Detailed Field Survey Overview

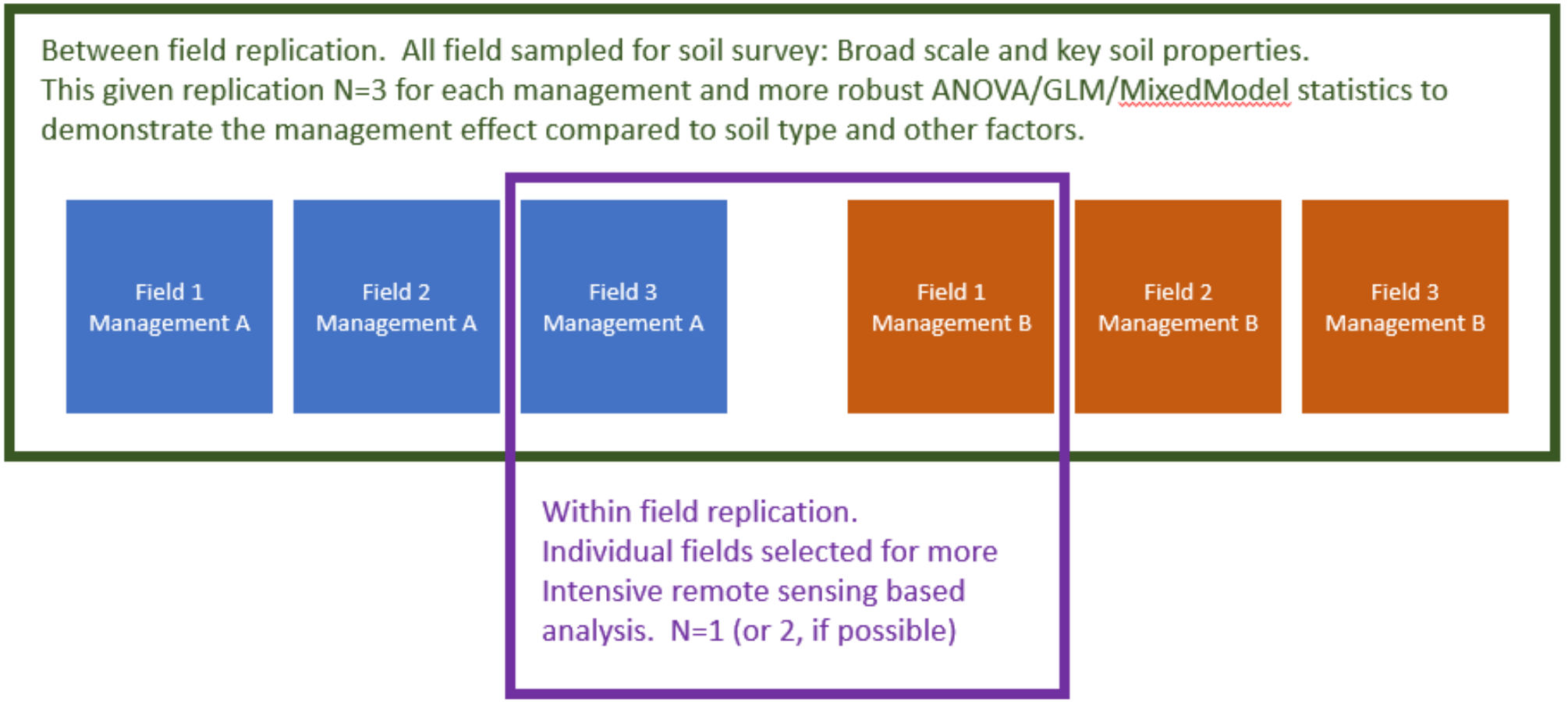
Research Design: Framework of NFM measures and measurements

LANDWISE NFM

- Greater spatial and temporal detail to capture field-scale heterogeneity under different land-based NFM measures
- Multiple sampling periods over an annual cycle at 3 focussed sites

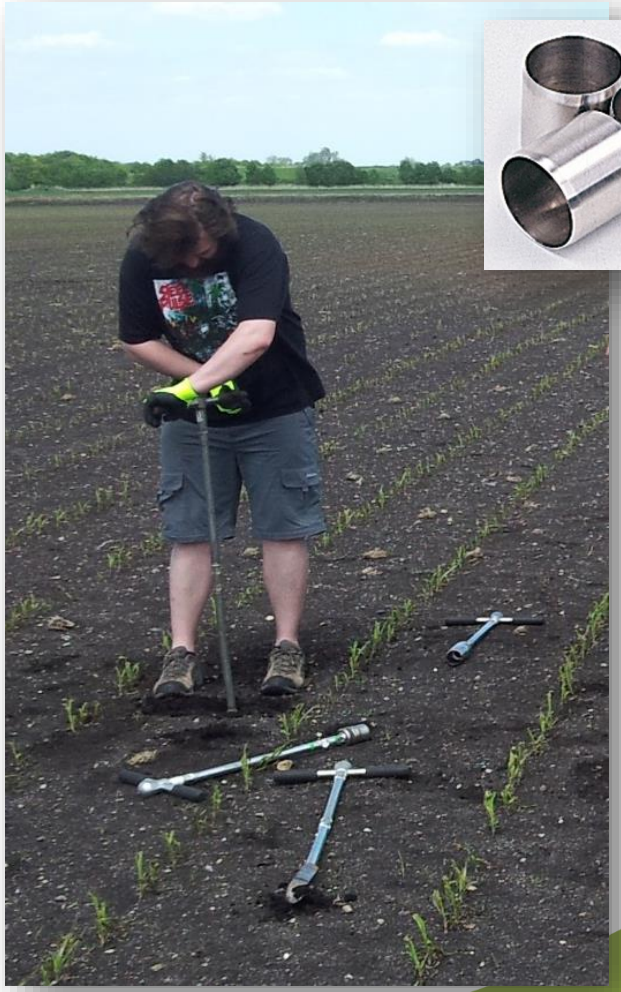
Land-based NFM measures	
Soil/Geology	Management
Shallow soils on Cotswold limestone *Sandy loam/ sandy silt loam*	1. Arable without grass 2. Arable with grass (rye & clover) 3. Arable with grass (herbal ley) *Crop: Winter wheat/barley*
Medium soils on Chalk *Loams*	1. Controlled traffic & diverse rotation 2. Conventional *Winter cereals*
Heavy soil on mudstone *Clays*	1. Broadleaf woodland 2. Permanent pasture *Rye grass*

Sampling strategy and statistical design



Soil sampling with depth

- Soil samples collected at 5 depths between the surface and 100 cm depth (where possible)
- Analysis in the lab for bulk density, organic matter and soil moisture retention



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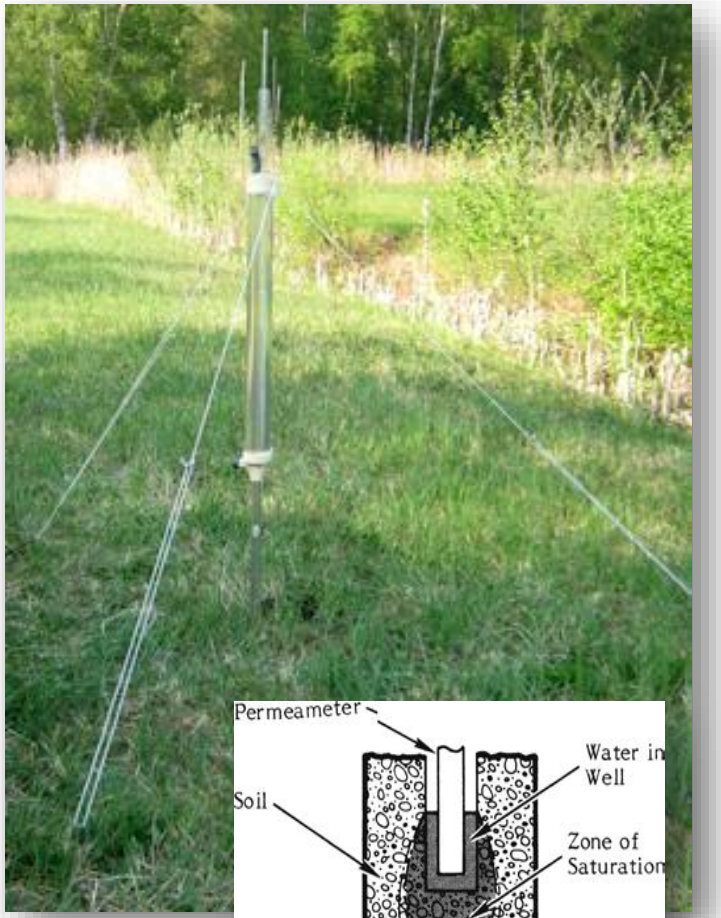
Infiltration rate and hydraulic conductivity

- Testing how fast water moves in to the soil
- Surface infiltration rate (Kunsat) using mini disk tension infiltrometers
- Saturated hydraulic conductivity (Ksat) at 25 cm and 45 cm depth



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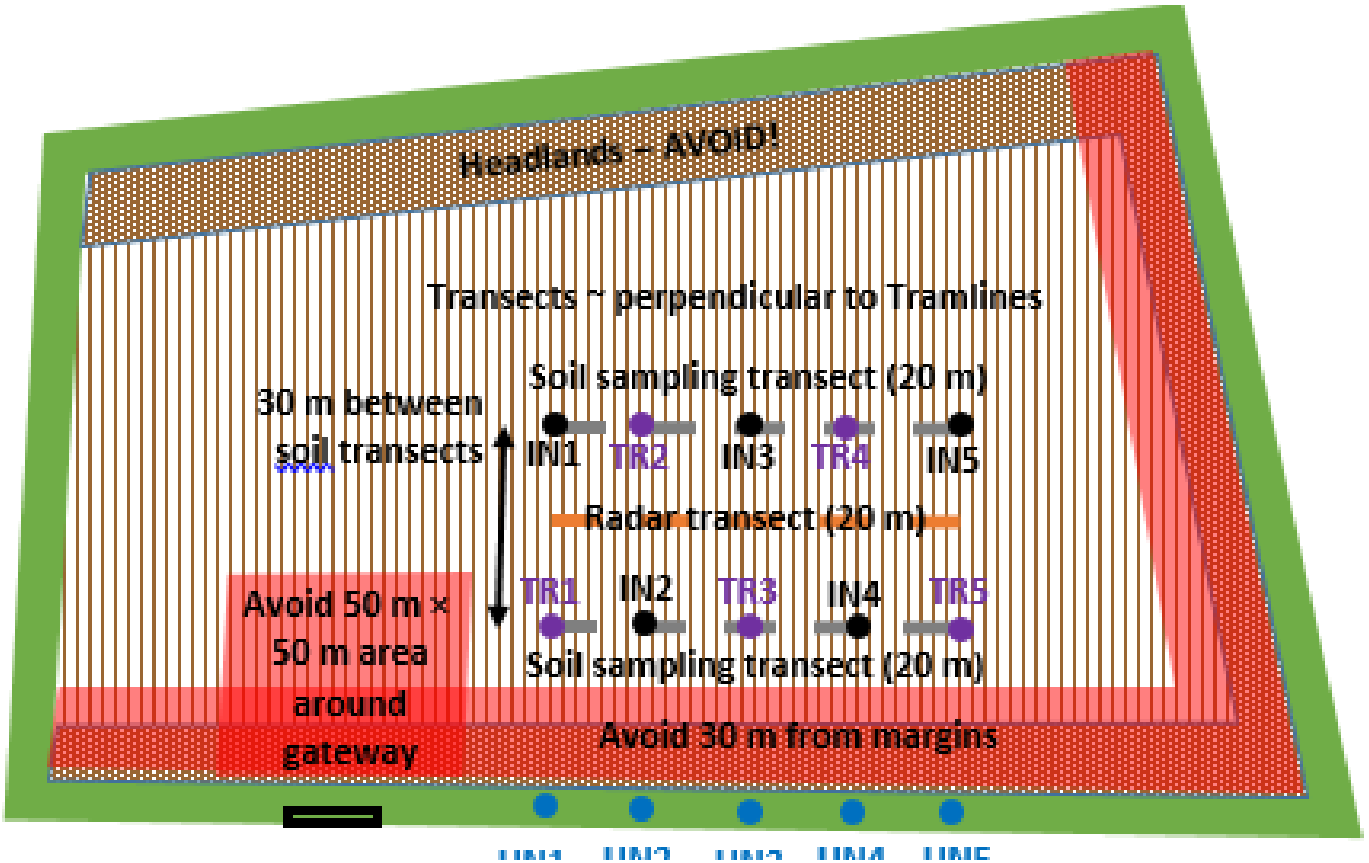
Soil and vegetation root depth

- Soil cores up to 100cm depth
- Determine soil depth and horizons
- Record vegetation root depth

Detailed Survey - methodology

- Soil and vegetation root depth at all locations
- Infiltration rate at infield and untrafficked
- BD, SOM, Ksat, retention samples taken at in field and trafficked sampling locations
- Over 2 transects either side of the ERT and radar transect location



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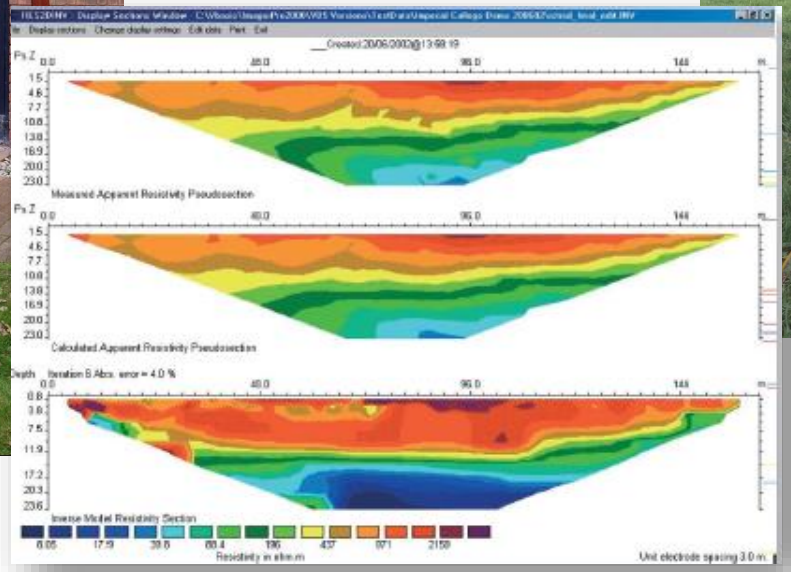
Soil moisture

- Portable radar rig, TDR & ERT probes
- Detailed surface coverage and soil depth to see variation over field



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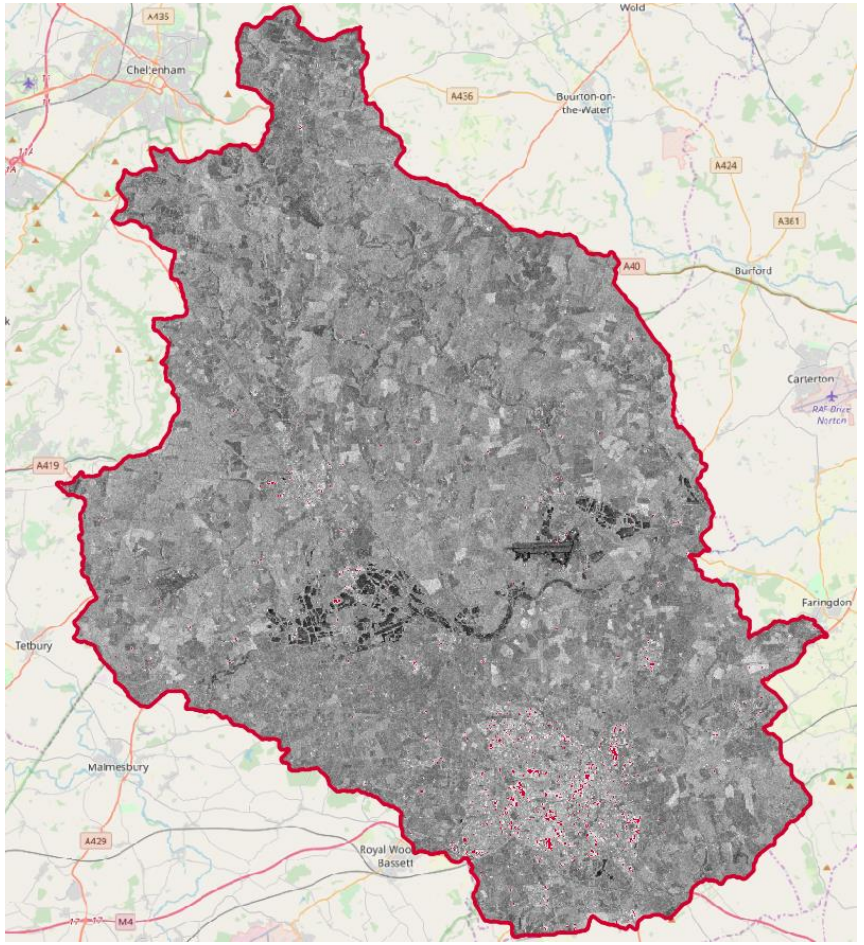
Drone measurements

- Multi-spectral survey to produce NDVI – vegetation growth/stress and crop stages
- RGB camera – orthophotos, DTMs, DEMs and surface roughness
- Thermal measurements

Field data used to compare to satellite data

- Satellite data will overlap with both portable rig and radar properties
- Regular repeat observations (8 orbits every 12 days)
- Independent of weather or daylight conditions
- Catchment-wide observations



<-25 dB 0 dB (>0 dB)

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- Thank you!

- emitri@ceh.ac.uk

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