Exploring field methods for the assessment of soil condition and soil function

Estimating ecosystem service and natural capital value across organic and conventional field sites

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Overview and aims:

- There is strong political, industry and academic interest in incorporating a natural capital (NC) approach into land management decision making and agricultural policy
- Whilst soil is recognised as a critically important component of NC, condition assessments often only include baseline soil properties, not soil functions or soil ecosystem services (ES) and the relationships between these are still poorly understood [1, 2]
- To move to a cost effective NC or ES approach for agricultural decision making and agri-environment policies, it is necessary to be confident in the relationships between soil conditions measured, likely soil function and corresponding ES delivered
- **This study aims to apply established frameworks** (Figure 1) to contribute to addressing these challenges by:
- Appling a range of field based assessments of soil function in order to explore the relationships between baseline soil quality parameters, soil function, land management and ES value
- Testing the application of these methods in addressing agricultural decisions. In this case; could the expansion of organic farming, despite its lower crop yields, deliver greater net benefit to society, than conventional farming?

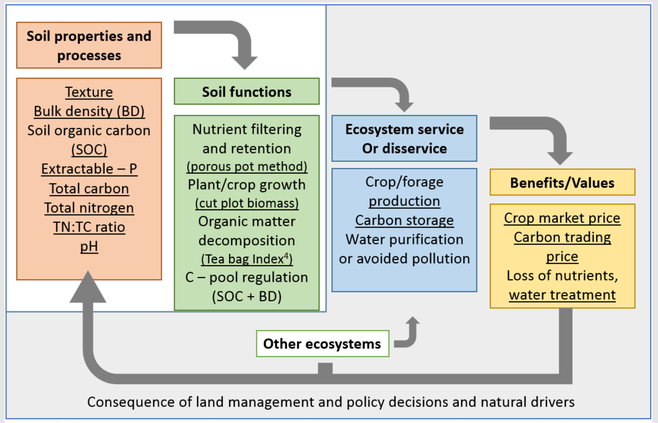

Figure 1: *Flow pathway for the functional valuation and assessment of soil natural capital (its component properties), soil functions, ecosystem services and benefits to society. The diagram includes the metrics at each stage applied in this study. Framework developed by Haines-Young and Potschin (2008) [3], as shown in Greiner et al., (2017) [2] .*

Methods:

- Nine conventional (con) and nine organic (org) fields were selected on the Estate covering the main rotational land uses
- All fields were on the same soil series, a well-drained coarse loamy to sandy soil widespread in the UK
- Three sites were selected within each field informed by previous sampling results
- Soil samples were collected in Autumn 2018 for analysis of a suite of commonly used soil condition indicators. Four soil functions were then selected for quantification/monitoring (see Figure 1 for the metrics used) at stages through 2018 - 2020
- Ecosystem service value data is in the process of being collected and will combine farm records, established farm gross margin data, carbon market prices and estimated water treatment costs **Thoughts on applying/incorporating these values very welcome**

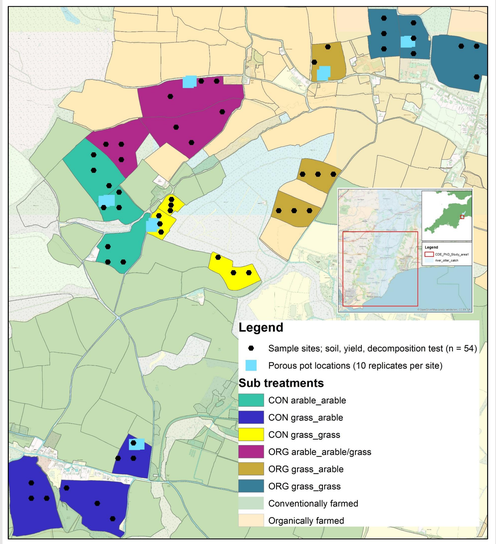

Figure 2: Map of the selected field sites at Clinton Devon Estates, SW England
Photos, left to right: Installing porous pots for the monitoring of soil pore water nitrate concentration to determine total nitrate loss; collecting maize yield samples ahead of harvest; red and green Lipton tea used in the TBI decomposition test

Preliminary results: Testing relationships between soil properties and functions

- Initial exploration of the data identifies that there are few strong relationships between the measured soil properties and the three soil functions presented across both org and con field sites (see Fig 4). Exceptions to this are the strong relationship between carbon storage and dependent variables, SOC and BD and pH and decomposition rate in con field sites (highlighted)
- Further modelling of relationships will be conducted once all soil property data are able to be processed and collated
- **Statistics advice/thoughts for comparing or modelling the relationship of different/multiple indicator properties and soil functions, whilst controlling out effects of treatment and sub treatment, very welcome**

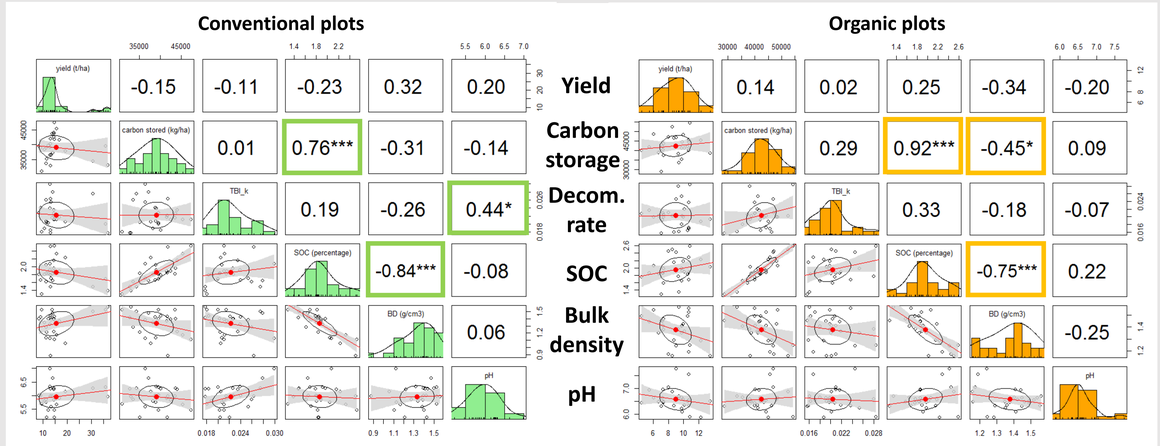

Figure 3: *Showing the relationship between the different soil properties and soil functions (excl. nitrate leaching data) for con and org sites. Left hand plots show data scatter charts with plotted linear regression and confidence intervals. Corresponding Pearson Correlation Coefficient statistic (r^2) are shown on the right, with significance levels shown as P = '***' 0.001 '**' 0.01 '*'0.05.*

Preliminary results: Detecting differences in organic and conventional soil functions

Data processing and analysis has recently been curtailed but preliminary analysis suggests:

- There are significant differences in the means (welch two sample t-test) between org and con field sites for all soil functions
- Cumulative yield is significantly higher on con sites (p = <0.05), delivering on average 58% greater biomass yield
- Despite lower yields carbon storage appears significantly higher (p = 0.014) and nitrate concentrations in leachate are significantly lower (p = < 0.001) across org fields, suggesting that, under current management org fields could deliver greater ES
- As this is a nested design, more complex models need running but initial linear mixed effect models and nested ANOVA (including field as a random effect) only support that yield has a significant relationship with treatment (p = <0.05)

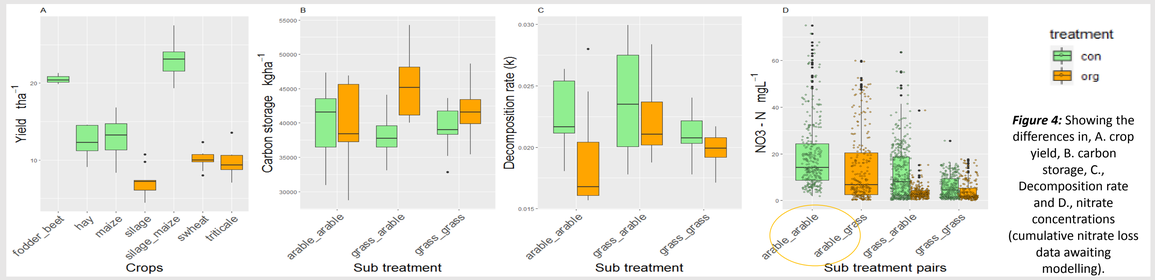

Figure 4: *Showing the differences in, A. crop yield, B. carbon storage, C., Decomposition rate and D., nitrate concentrations (cumulative nitrate loss data awaiting modelling).*

Concluding remarks and discussion prompts:

- Predicting soil functions based on a small suite of soil properties, apart from for estimating dependent functions, is complex and in this case not yet viable (further soil sample lab analysis and cumulative nitrate leaching modelling is required)
- Inclusion of economics data will allow a more detailed assessment of the value of these ES and an assessment of whether they offset org farming's significantly lower yields (linking these ES to soil function/mgmt. is complex – advice is welcome)

References: [1] Baveye *et al.,* (2016) 'Soil "Ecosystem" Services and Natural Capital: Critical Appraisal of Research on Uncertain Ground', Frontiers in Envi Science, 4 (June), pp. 1–49 doi.org/10.3389/fenvs.2016.00041 [2] Greiner *et al.,* (2017) 'Soil function assessment: review Of methods for quantifying the contributions of soils to ecosystem services', Land Use Policy. Elsevier, 67 (May) , pp. 224–237. doi.org/10.1016/j.landusepol.2017.06.025 [3] Haines-Young, R., Potschin, M., (2008) England's Terrestrial Ecosystem Services and the Raionale for an Ecosystem Approach. Full Technical Report to Defra. Department for Environment Food and Rural Affairs. (Defra) pp. 89.[4] Keuskamp *et al.,* (2013), Tea Bag Index: a novel approach to collect uniform decomposition data across ecosystems. Methods Ecol Evol, 4: 1070-1075. doi:10.1111/2041-210X.12097