iCASP
Integrated Catchment Solutions Programme

Soil Health
12th February 2019

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NERC SCIENCE OF THE ENVIRONMENT

Soil Health

RES2 Measurements to establish changes to soil infiltration and storage

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Combination of these methods which should be comparable to the scale of the project.

- Simple soil pit examination three per field in representative areas of the whole i.e not in the margins or heavily trafficked areas (e.g. Visual Evaluation of Soil Structure (VESS) for Soil Health)
- Review of past soil compaction surveys if available
- Anecdotal survey/photos showing off site impacts linked to accelerated runoff
- Photos and observations during and after rain at the field scale
- Anecdotal information on drought resilience
- Observations from farmers on duration of soil saturation and any notable changes in this
- Infiltration using a simple open pipe or Mini disc tension infiltrometer
- Worm counts
- Bulk Density
- Soil Health indices
- Soil moisture probe before and after implementation and soil moisture data from tensiometers / probes
- Surface roughness changes

- Surveys grouped into: low, medium and accelerated runoff
- Organic matter content as indicator of soil health and water holding capacity
- Soil compaction assessment pre- and post-land use / land management change using soil pits and standard NSRI methodology (e.g. degradation Low, Medium, High or Severe) (Holman, et al., 2001)

Soil Health: Existing data and anecdotal evidence

- Review of past soil compaction surveys if available
  - Who has this data?
- Anecdotal survey/photos showing off site impacts linked to accelerated runoff
  - Any evidence of soil and rocks being deposited
- Photos and observations during and after rain at the field scale
  - Overland flow paths, erosion features, standing water
- Anecdotal information on drought resilience
  - Differences in vegetation
- Observations from farmers on duration of soil saturation and any notable changes in this
  - Requires ad hoc contact with farmers to discuss this. Would work best is approached at start
- Surveys grouped into: low, medium and accelerated runoff
  - Requires some guidance as could be highly subjective

Soil Health: Field Measurements

- Simple soil pit examination three per field in representative areas of the whole i.e not in the margins or heavily trafficked areas (e.g. Visual Evaluation of Soil Structure (VESS) for Soil Health)
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- Worm counts
- Bulk Density
- Soil compaction assessment pre- and post-land use / land management change using soil pits and standard NSRI methodology (e.g. degradation Low, Medium, High or Severe) (Holman, et al., 2001)
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Visual Evaluation of Soil Structure

Soil structure affects root penetration, water availability to plants and soil aeration. This simple, quick test assesses soil structure based on the appearance and feel of a block of soil dug out with a spade.
The scale of the test ranges from Sq1, good structure, to Sq5, poor structure.

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Equipment:
Garden spade approx. 20 cm wide, 22-25 cm long.
Optional: light-coloured plastic sheet, sack or tray ~50 x 80 cm, small knife, digital camera.

When to sample:
Any time of year, but preferably when the soil is moist. If the soil is too dry or too wet it is difficult to obtain a representative sample.
Roots are best seen in an established crop or for some months after harvest.

Where to sample:
Select an area of uniform crop or soil colour or an area where you suspect there may be a problem. Within this area, plan a grid to look
at the soil at 10, preferably more, spots. On small experimental plots, it may be necessary to restrict the number to 3 or 5 per plot.

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Method of assessment:

Step	Option	Procedure
Block extraction and examination		
1. Extract soil block	Loose soil	Remove a block of soil ~15 cm thick directly to the full depth of the spade and place spade plus soil onto the sheet, tray or the ground
	Firm soil	Dig out a hole slightly wider and deeper than the spade leaving one side of the hole undisturbed. On the undisturbed side, cut down each side of the block with the spade and remove the block as above.
2. Examine soil block	Uniform structure	Remove any compacted soil or debris from around the block
	Two or more horizontal layers of differing structure	Estimate the depth of each layer and prepare to assign scores to each separately.
Block break-up		
3. Break up block (take a photograph - optional)		Measure block length and look for layers. Gently manipulate the block using both hands to reveal any cohesive layers or clumps of aggregates. If possible separate the soil into natural aggregates and man-made clods. Clods are large, hard, cohesive and rounded aggregates.
4. Break up of major aggregates to confirm score		Break larger pieces apart and fragment it until a piece of aggregate of 1.5 - 2.0 cm. Look to their shape, porosity, roots and easily of break up. Clods can be broken into non-porous aggregates with angular corners and are indicative of poor structure and higher score.
Soil scoring		
5. Assign score		Match the soil to the pictures category by category to determine which fits best.
6. Confirm score from:		Factors increasing score:
	Block extraction	Difficulty in extracting the soil block
	Aggregate shape and size	Larger, more angular, less porous, presence of large worm holes
	Roots	Clustering, thickening and deflections
	Anaerobism	Pockets or layers of grey soil, smelling of sulphur and presence of ferrous ions
	Aggregate fragmentaion	Break up larger aggregates ~ 1.5 – 2.0 cm of diameter fragments to reveal their type
7.Calculate block scores for two or more layers of differing structure		Multiply the score of each layer by its thickness and divide the product by the overall depth, e.g. for a 25 cm block with 10 cm depth of loose soil (Sq1) over a more compact (Sq3) layer at 10-25 cm depth, the block score is (1 x 10)/25 + (3 x 15)/25 = Sq 2.2.

Scoring: Scores may fit between Sq categories if they have the properties of both.
Scores of 1-3 are usually acceptable whereas scores of 4 or 5 require a change of management.

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Soil Health: VESS

Field Recording Form, Visual Evaluation of Soil Structure (Ball et al., 2007; after Pulido)

Observation number:

Date: ______________________

Described by: ______________________ **Location:** ______________________

Plot: ______________________ **Depth (cm) of the block:** ______________________

Crop: ______________________ **Difficulty of extraction** ______________________

Layers (cm)	**Layer 1** **layer 2** **layer 3**
Block extraction	Loose soil / Firm soil
Examine soil block	Uniform structure / horizontal layers
Block break -up	
	Clods are large, hard, cohesive and rounded aggregates
	Aggregates shape
	Aggregate porosity
	Roots
	Easily of break-up
	Anaerobism
Appearance of reduced fragments	
Aggregate shape and size	Large / small / held by roots / rounded/ angular / less porous / porous / presence worm holes
Roots	
Clustering	Few / Common / Many
Thickening (root deformation)	None / weak / Common
Deflections	None / Weak / Strong
Distribution	Uniform / surface layer
Score	
Match the soil to the pictures category	**Layer 1** **layer 2** **layer 3**
Confirmed score	

Infiltration

Open pipe: cheap, simple, quick, less accurate

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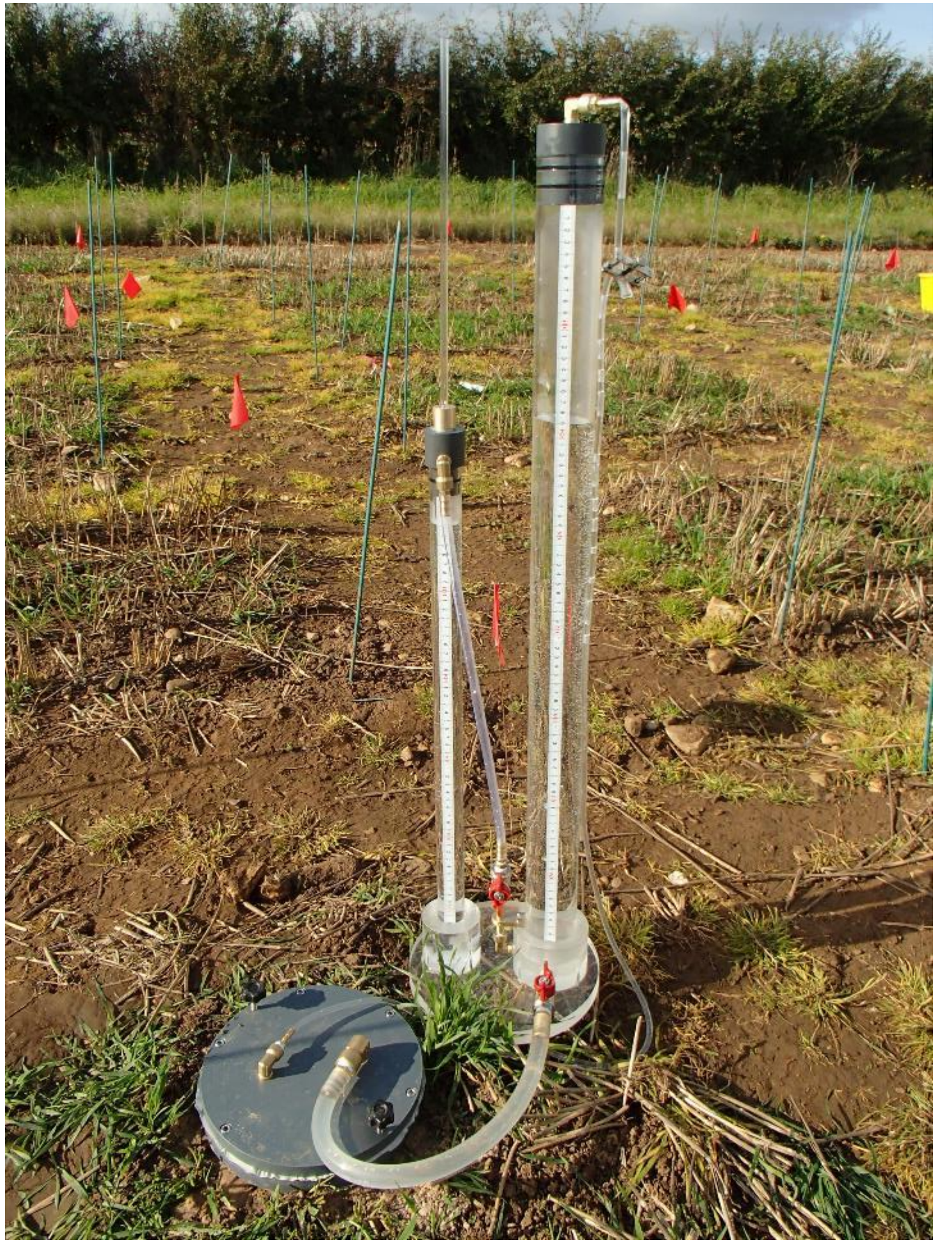
Infiltration

Tension infiltrometer:

fairly cheap, simple, quick, more accurate measure of hydraulic conductivity

Can be time consuming to collect data



Saturated hydraulic conductivity

Speed with which water moves through the soil

Can measure in the lab but requires careful sample collection

Worm Counts

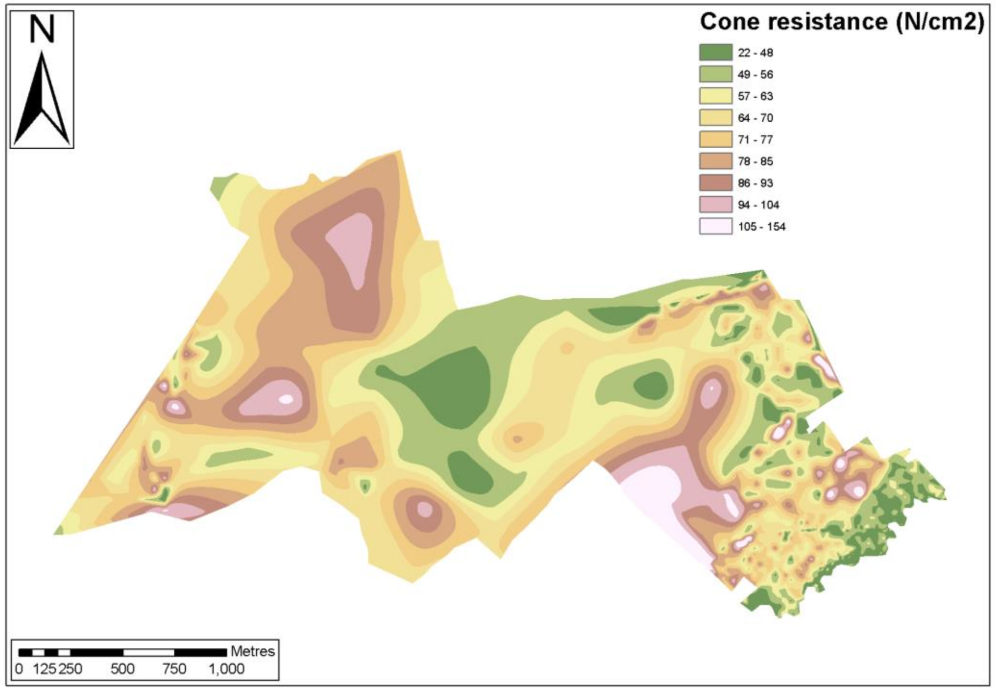
- Good fun
- Can be time consuming
- Numbers are affected by antecedent conditions, particularly soil moisture

Soil Compaction

- Valuable information on a soils ability to infiltrate water
- Can be very simple – but simple approaches might not allow quantification
- Numerous measurements required to get an accurate measure of compaction

Soil Compaction - penetrometer

Allows spatial pattern of compaction to be analysed
Can be time consuming
Affected by soil moisture
Fairly expensive kit



Soil Moisture

Soil moisture probe: before and after implementation
Individual before and after measurements of little value as values are highly dependent on antecedent conditions

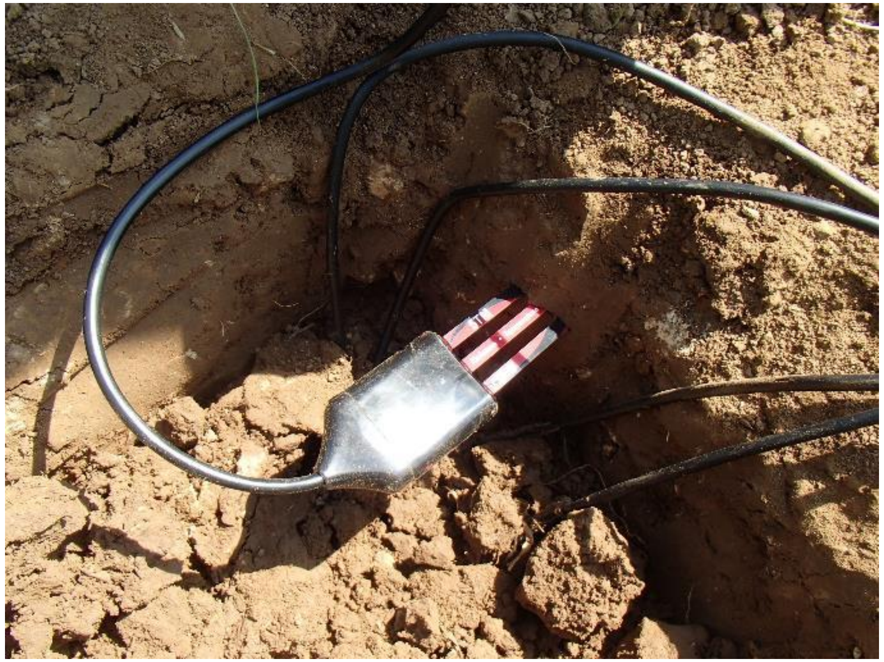
Soil moisture sensors

Temporal variability in soil moisture

Good sampling design can provide valuable information on response to storm events, water movement and availability

Suitable logger required –can be expensive

Local calibration required – need lab access



Soil Health: Lab Measurements

Bulk Density:

The weight (mass) of soil per unit volume

Simple gravimetric test but requires lab access to oven and balance

Organic Matter Content: indicator of soil health and water holding capacity

Relatively small increase in OM can result in significant increases in water holding capacity

Fairly straightforward analysis but requires lab access

Wet oxidation *i.e.*, Walkley-Black (WB) method: relatively accurate, and popular, time-consuming, costly, high potential to cause environmental pollution

Loss-on-ignition (LOI) simple, cheap, no acid waste

Soil Health: Lab Measurements

Soil Water Holding Capacity (WHC): determined volumetrically or gravimetrically

Volumetric method is slightly less accurate than gravimetric

Both require access to lab equipment

Soil Health: Soil Health Indices

Typically a mixture of field and lab measurements

A list of the most commonly used indicators for soil health:

Biological indicators	Chemical indicators	Physical indicators
Soil organic matter (SOM)	Nitrogen (N): mineralised N (N-min), ammonium (NH4+), nitrate (NO3-)	Soil structure (e.g. aggregate stability)
Number and diversity of macro- and microorganisms	Macro-nutrients: phosphorus (P), potassium (K), magnesium (Mg)	Compaction
Number and diversity of Mycorrhiza (AMF), and root colonisation	Micro-nutrients: e.g. iron (Fe), copper (Cu), boron (B), manganese (Mn), etc.	Erosion
Number and diversity of earthworm populations	pH	Water-logging
Respiration rates	Electrical conductivity (EC)	
Enzymatic activity	Cation exchange capacity	
Microbial profiling	Salinity	

Gathering views from community members on natural-based mechanisms to mitigate risk of flooding

Why and How?

1) In the “scoping survey”, you raised the desire to better understand the co-benefits delivered by NFM interventions, and in particular the social benefits, which are not well known
2) EA requires you to think of how to monitor co-benefits of NFM

→ We have designed **a survey designed at community members**, which aims to understand:

i) How communities feel engaged by the pilots in NFM

ii) How they understand about NFM interventions

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Use and dissemination of the survey

Data from this survey will be beneficial:

- For the iCASP NFM project to monitor impact on community
- For you the pilots:
  - To prepare for the EA monitoring guidance’ requirement
  - To develop engagement strategies suitable to the need of the community
  - As part of developing the community of practice

The survey will be made online within the next few weeks.

Help us diffuse it through your community members!

On paper, via emails, **any view?**

We will forward you the link to the survey in due time

Respondents will receive a useful report back from this

Any questions: iCASP@leeds.ac.uk

THANK YOU!

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Appendix: Detail on the type of data the survey gathers:

- Experience of community members with flooding
- Familiarity with the notion of NFM
- NFM engagement and perception
- Participation into the design/implementation of NFM measures, and possible challenges to participation

Questions and Answer Session