Centre for Sustainable Cropping

Arable Transitions Toolkit

Cathy.Hawes@hutton.ac.uk

Step 1: Goal setting/priorities

Soil health – Biodiversity – Yield

Goal

Soil physical structure & biological function for better yields, with less fertiliser and pollution

physics → **Mechanism**

Water holding capacity, infiltration, aggregate stability, soil pore diversity, lower bulk density

biology →

Microbiome diversity, decomposition, symbiotic associations (mycorrhizae, rhizobia), antagonists

Management options check list:

- Organic matter amendments ✓
- Conservation tillage ✓
- Cover cropping Green manure ✓
- Legumes Under-sowing ✓

Step 1: Goal setting/priorities

Soil health – **Biodiversity** – Yield

Goal

Integrating biodiversity into crop production to reduce agrochemical reliance

Crop | Native spp

Mechanism

- Crop diversity to enhance yield enhancement through niche differentiation, facilitation and apparency
- Weed and field margin diversity for ecosystem services (pollination, biocontrol, soil processes)

Management options check list:

- Legume undersowing ✓
- Co-cropping & inter-cropping ✓
- Diversified field margins ✓
- In-field broad-leaved weeds ✓

Step 1: Goal setting/priorities

Soil health – Biodiversity – **Yield**

Goal

Maintaining yield with less inputs through nutrient management and crop protection

Crop nutrition | *Crop protection*

Mechanism

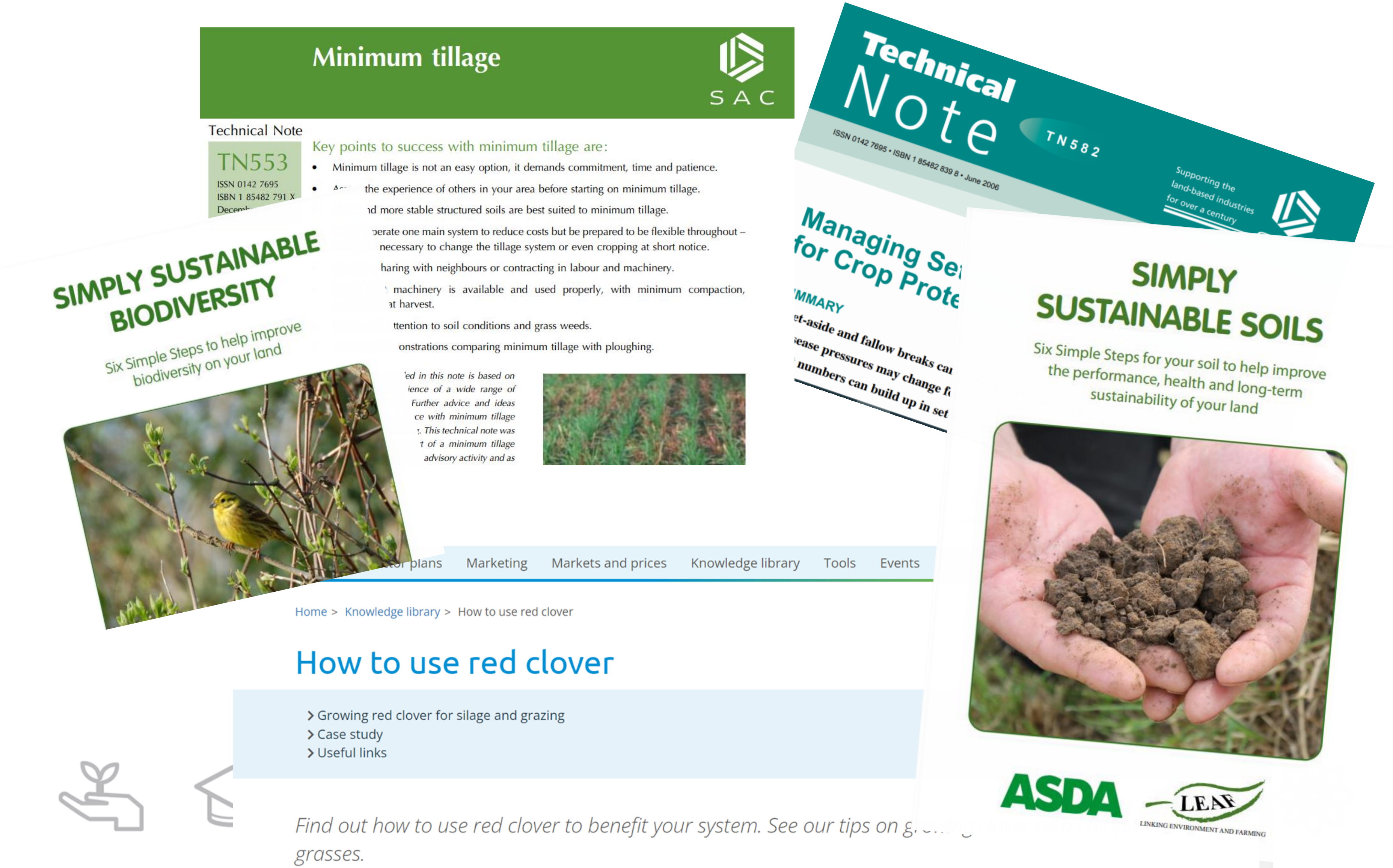
- Utilising soil health for better plant nutrition, precision agriculture
- Resilient and resistant crop varieties through nutrition and breeding, IPM

Management options check list:

- [x] Legumes for BNF
- [x] Soil N Supply measurement
- [x] Fert timing and placement
- [x] Biofortification and nutrition

Searchable Resource Library

linked to management options selected by user

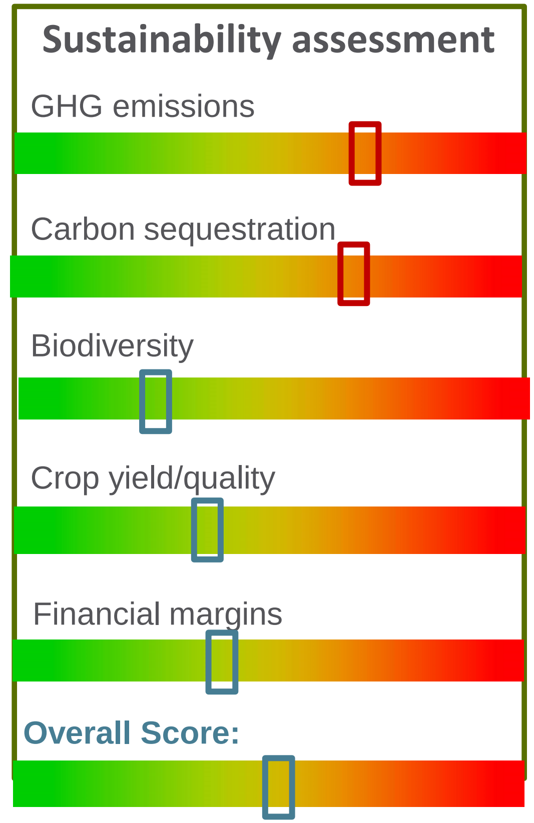


Step 2: Predict sustainability impact

Checklist of options linked to DEXi model

Integrated management options

- ❑ Soil carbon amendments
- ❑ Cultivations – direct drill
- ❑ Co-cropping, intercropping
- ❑ Variety selection
- ❑ Precision ag options
- ❑ Fertiliser alternatives
- ❑ IPM strategies, threshold monitoring
- ❑ Biofortification
- ❑ Weed management
- ❑ Margins and buffers
- ❑ Habitat/resource provision



Step 3: Baselining to monitor change

Resource library for monitoring linked to selected management options

Step 4: Implementation and impact assessment

- Implement on farm

- Monitor using same indicator protocols

- CSC dashboard: analysis of impact on indicators over time – costs, benefits and risks

Processes

- Minimising inputs
- Optimising resource use efficiency
- Reducing losses

Outputs

- Biodiversity gains
- Soil quality
- Yield

Minimising inputs: crop protection

Engineered solutions

Biofortification for crop resilience: Preliminary data indicate less *Septoria* infection in winter wheat compared with standard fungicide treatment.

Contact: Andrew Christie

Disease forecasting: Blight sprays down by 1 to 4 a year using the Hutton Criteria and "One Class" model to predict risk.

Contact: Alison Lees

Minimising inputs: crop protection

Biodiversity-based solutions

Diverse field margins: provide habitat for insect predators and floral resources adult forms of Dipteran and parasitoid natural enemies.

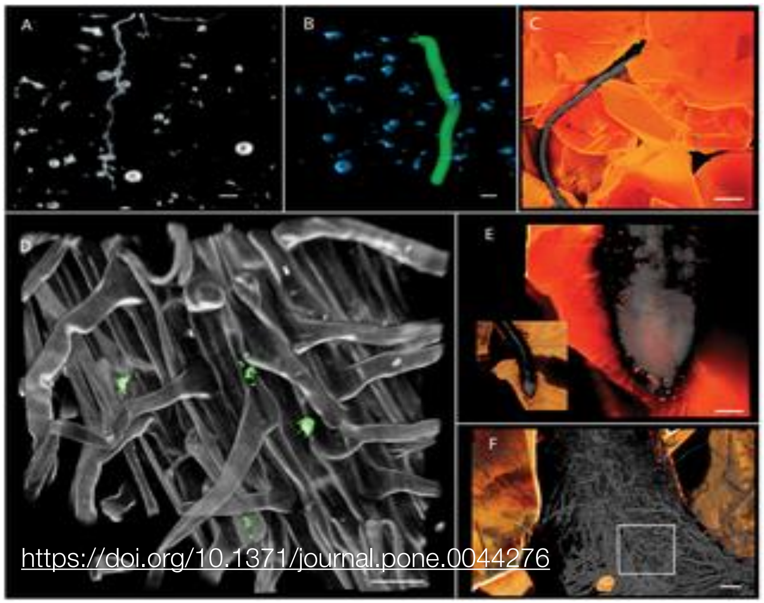
Contact: Cathy Hawes

Weed biodiversity: supports diverse foodwebs, regulating pest populations through competition with non-pest herbivores and predation by natural enemies.

Contact: Cathy Hawes

Minimising inputs: crop protection

Biodiversity-based solutions



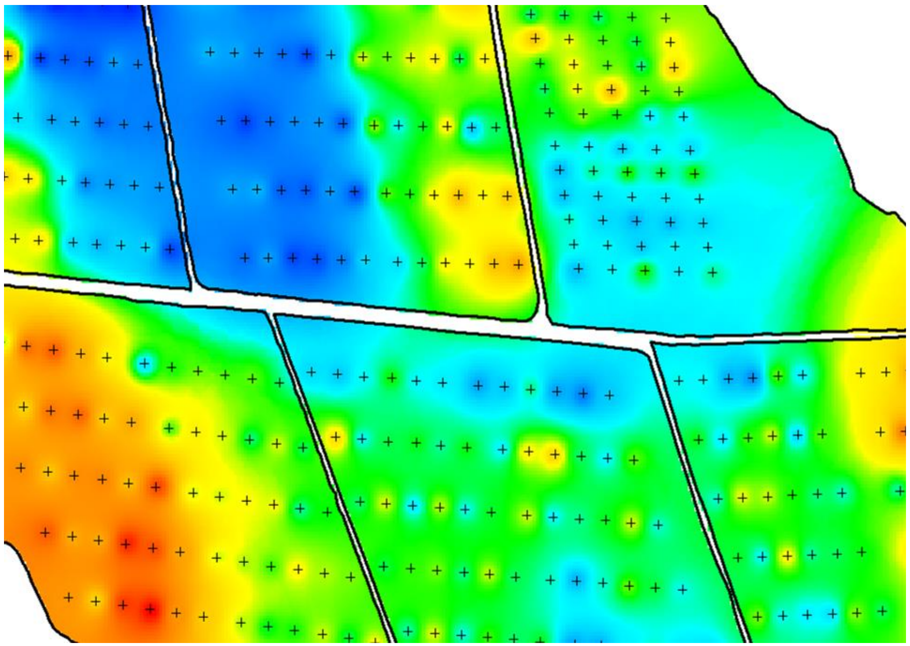
Soil biodiversity: organic matter & reduced disturbance generate diverse microbial communities with pest suppressive properties (antagonistic with soil borne pathogens).

Crop diversity: canopy heterogeneity in mixed varieties/species of crop reduces apparency to pests and disease, minimising population spread through fields.

Contact: Maddy Giles, Jennie Brierley

Contact: Ali Karley, Adrian Newton

Minimising inputs: fertiliser



Soil Nitrogen Supply used to calculate N input requirements; timing of application targeted for max growth periods. Results in ca. 40% reduction in mineral N input.

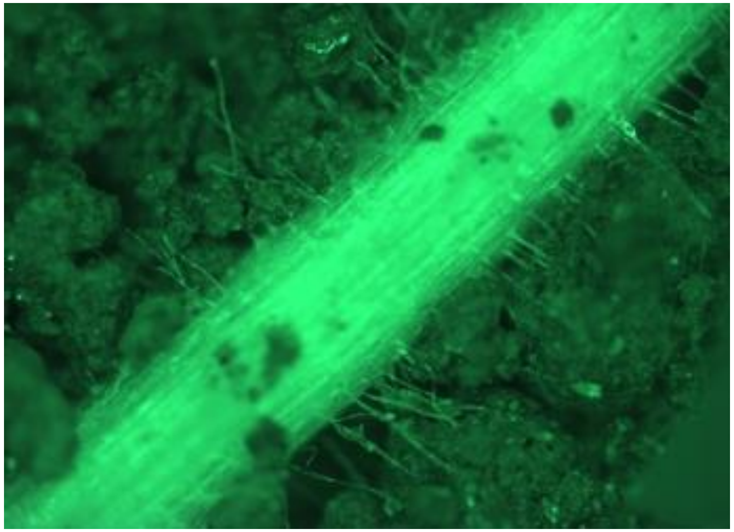
Contact: Andrew Christie

Biological Nitrogen Fixation by Faba bean and under-sown clover can reach > 200 kg ha^{-1} yr^{-1} leaving up to 50 kg ha^{-1} yr^{-1} residual N in soil post-harvest.

Contact: Pete Iannetta, Euan James

Optimising efficiency

Reduced soil disturbance and diverse carbon inputs (weeds, cover crops, crop residue and compost):



Improved soil structure for better crop rooting and nutrient/water uptake efficiency: pore diversity, aggregate stability and water holding capacity are increased, bulk density is lower.

Contact: Tracy Valentine

Increased microbial biomass, mycorrhizal fungi and macro-invertebrate abundance resulting in faster rates of decomposition and nutrient availability.

Contact: Tim George, Cathy Hawes

Minimising losses: in-field

Nitrogen losses from arable systems: ~280 kg N ha^{-1} yr^{-1} , 50% from erosion, runoff and GHG emissions

- Organic matter inputs + reduced tillage - improve soil structure, reducing erosion
- Tied-ridging - increased water infiltration, reducing run-off
- Cover crops - retain nutrients over-winter, reducing leaching
- Plant diversity - better resource use efficiency, reducing GHG emissions and leaching




Minimising losses: field boundaries

Multi-functional margins take up leached nutrients and minimise GHG emissions.

Contact: Tim George, Tim Daniel, Cathy Hawes

Engineered riparian buffers to slow movement of water from fields into natural watercourses, using coppiced willow/alder to take up excess nutrients; NBS-AIMS (D2)

Contact: Marc Stutter, Mark Wilkinson, Ken Loades

"Magic margins" developed by farm team win RSPB Nature of Scotland Innovation Award.

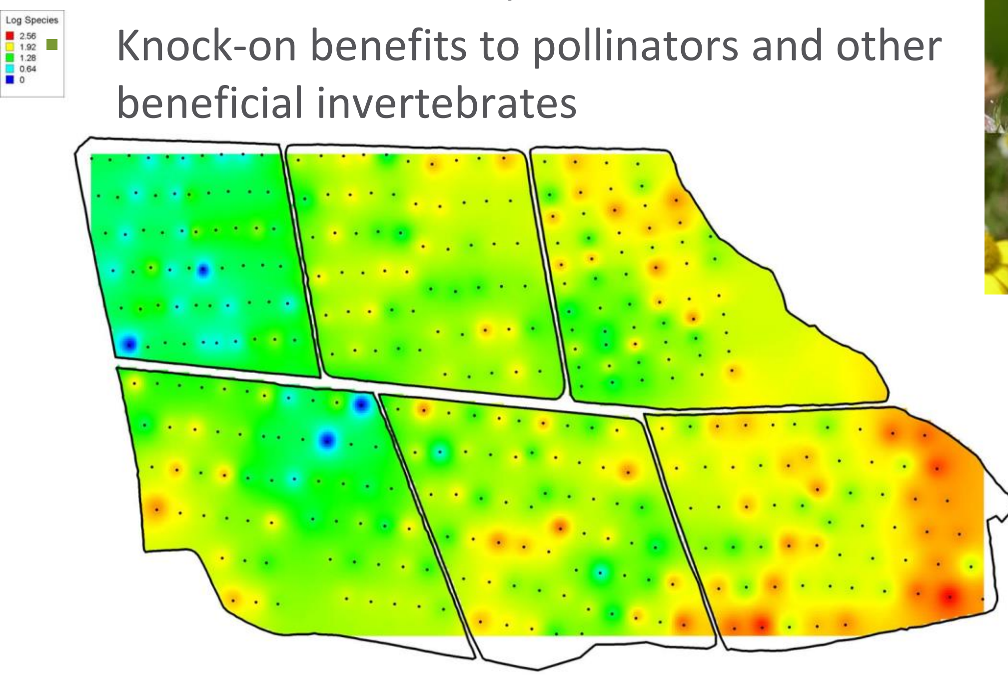
Contact: Euan Caldwell

Outputs: yield

- Yields comparable to national averages (Squire et al. submitted)
- 1st rotation – 1 t/ha yield penalty in winter wheat; no significant effect on other crops (Hawes et al. 2018, 2019)
- 2nd rotation – analysis to follow 2023
- Modelling work with Jagadeesh and Mohamed
- Differences in varietal responses to management
  - Deeper rooting cereal varieties perform better in integrated system (no-till) in extreme years (Newton et al. 2021)
  - Variation in BNF by faba bean varieties (Maluk et al. 2022)
  - Nutritional variation between potato cultivars, but no treatment effects (Frietag et al. 2016)

Outputs: biodiversity

- More (beneficial) dicot weeds in soil seedbank
- No overall effect of cropping system on grass weed seedbank, but more following wheat and bean crops
- Knock-on benefits to pollinators and other beneficial invertebrates

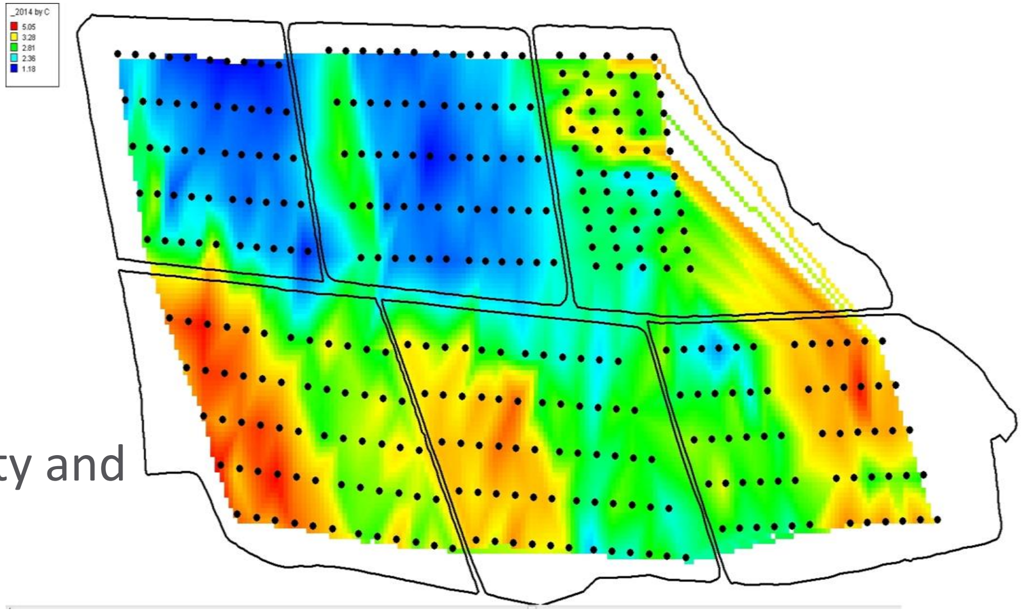


Species richness in weed seedbank

Drone/phone imaging for automated diversity assessment

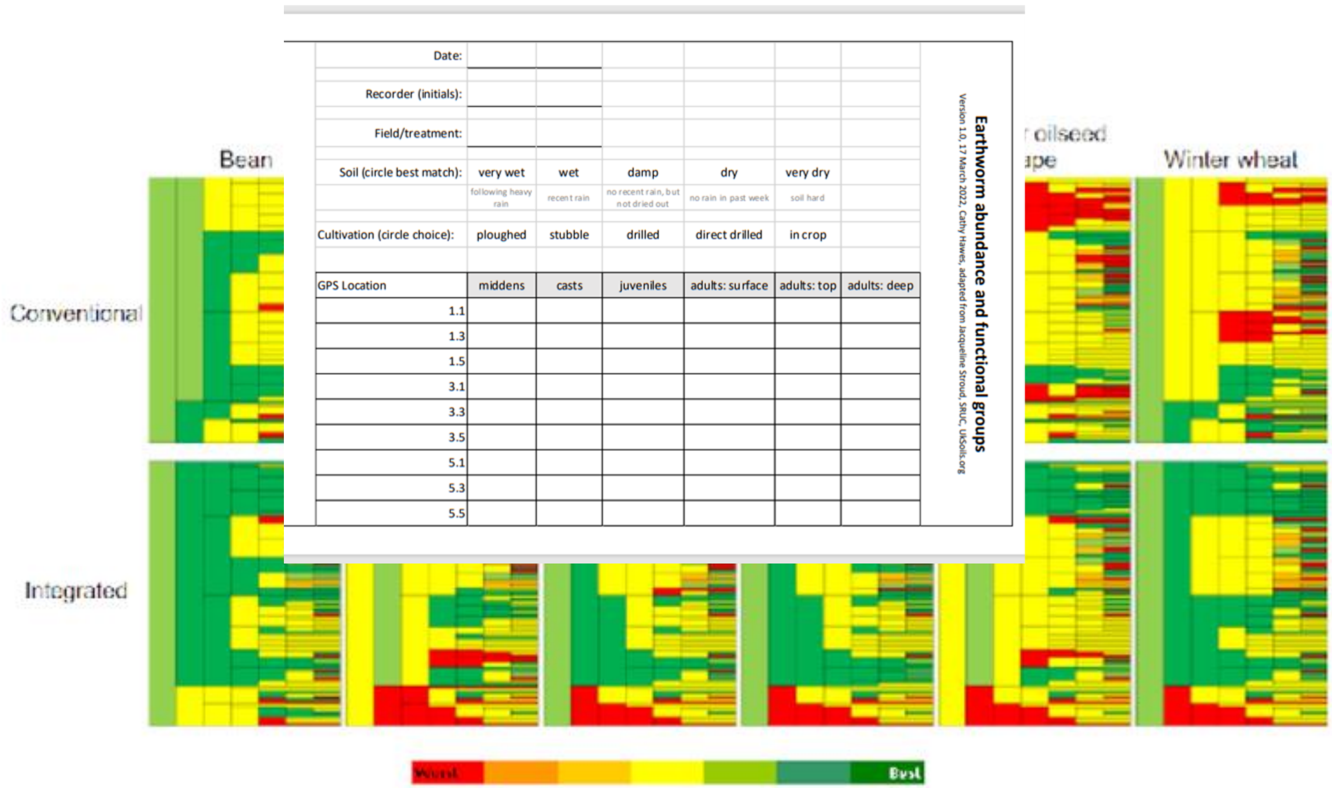
Outputs: soil

- More soil organic matter
- Positive correlation with litter decomposition rates
- Enhanced biological activity
  - earthworms, mycorrhizae, pest suppression
- Aggregate stability, pore size diversity and bulk density improves



Step 5: whole-systems assessment

- Data entry form for farmers/consultants
- Feed into automated summary stats/ farm report
- Sustainability assessment via DEXi-CSC
- 97 input variables; 332 aggregate variables
- Compares overall sustainability and components across cropping systems



Date:						
Recorder (initials):						
Field/treatment:						
Soil (circle best match):	very wet	wet	damp	dry	very dry	
	following heavy rain	recent rain	no recent rain, but not dried out	no rain in past week	soil hard	
Cultivation (circle choice):	ploughed	stubble	drilled	direct drilled	in crop	
GPS Location	middens	casts	juveniles	adults: surface	adults: top	adults: deep
1.1						
1.3						
1.5						
3.1						
3.3						
3.5						
5.1						
5.3						
5.5						

CSC

The James Hutton Institute

Contact Cathy.Hawes@hutton.ac.uk for more information

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