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Achieving Sustainable Agricultural Systems

Richard Pywell, Sam Cook & Ben Woodcock

25th Jan 2024

UK Centre for Ecology & Hydrology

ROTHAMSTED RESEARCH

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- 6 year Government funded research programme
- Uniting expertise in crop and environmental science, with support from the farming industry
- Co-develop ecologically-based sustainable agricultural systems that are efficient & resilient to future shocks
- Provides data, tools & a long-term research infrastructure for the farming industry

UK Centre for Ecology & Hydrology | ROTHAMSTED RESEARCH | BGS British Geological Survey | UKRI Biotechnology and Biological Sciences Research Council | UKRI Natural Environment Research Council

Improving biological pest control

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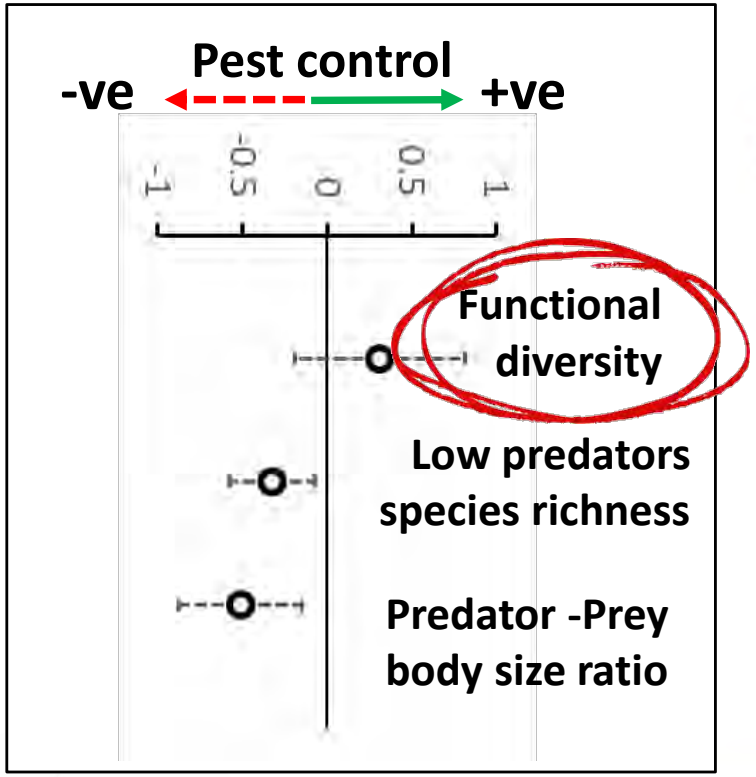
Diversity is the key to effective IPM

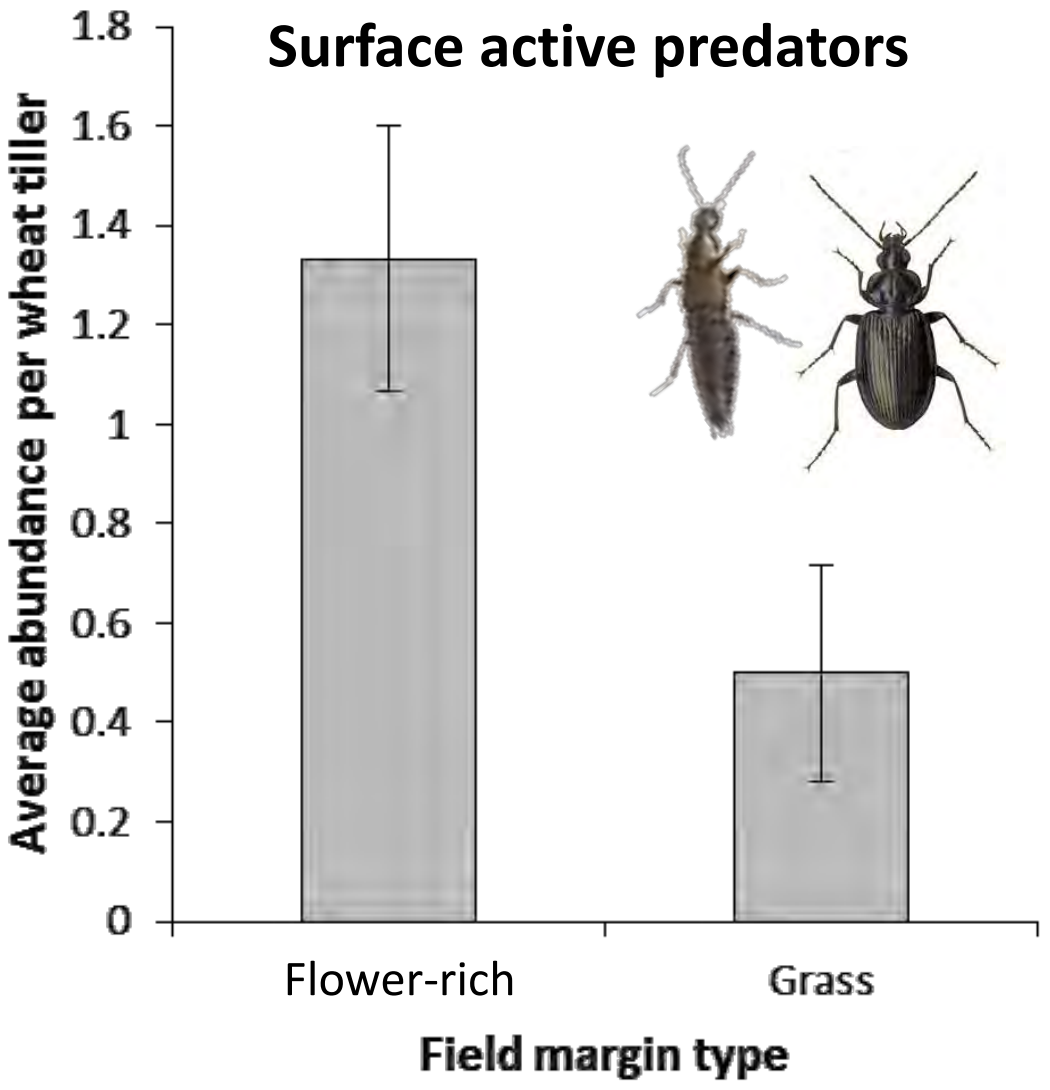
- Meta-analysis concluded natural pest control most effective where:
  - ➢ Management enhanced the functional diversity of predator traits / characteristics
  - ➢ Hunting strategy, prey preference, size, habitat (ground, foliage) etc



Snyder Biological Control 2019
Greenop et al. Ecological Applications 2018

Habitat for beneficials

- Study of four commercial farms comparing flower-rich *vs*. typical grass margins
- Sowing flowers **<u>increases</u>** abundance & diversity of 'beneficials'



Woodcock et al. Agriculture, Ecosystems, Environment 2016; https://doi.org/10.1016/j.agee.2016.06.023

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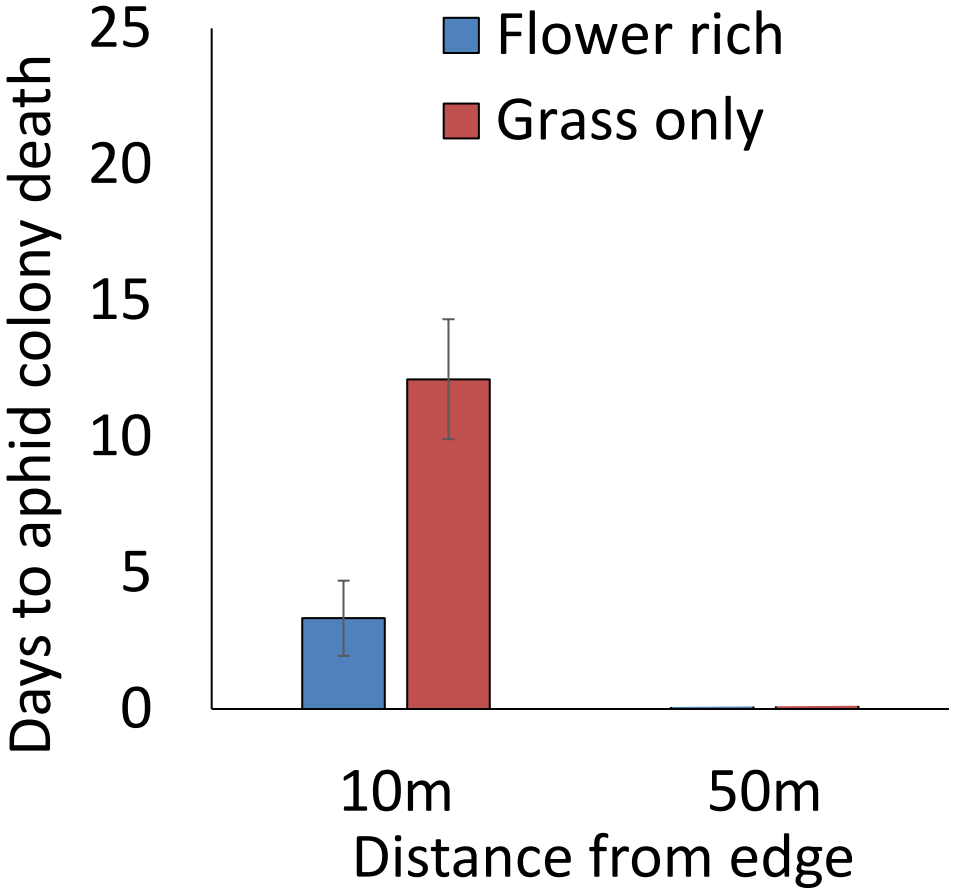
Flower-rich habitats support increased natural pest control

- Pest control from predators greatest adjacent flower-rich margins
- Spill-over of beneficials declines after 50m from field edge



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Woodcock et al. Agriculture, Ecosystems, Environment 2016; https://doi.org/10.1016/j.agee.2016.06.023

Diversity brings resilience in conventional farming systems

- Impact of field-realistic pesticide exposure on predator aphid feeding after 1 and 5 days
- This is a measure of how resilient individual species are to pesticides (toxicodynamics)

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Greenop, A., Cook, S.M., Wilby, A., Pywell, R.F. & Woodcock, B.A. (2020). Journal of Applied Ecology, 57, 2441-2453

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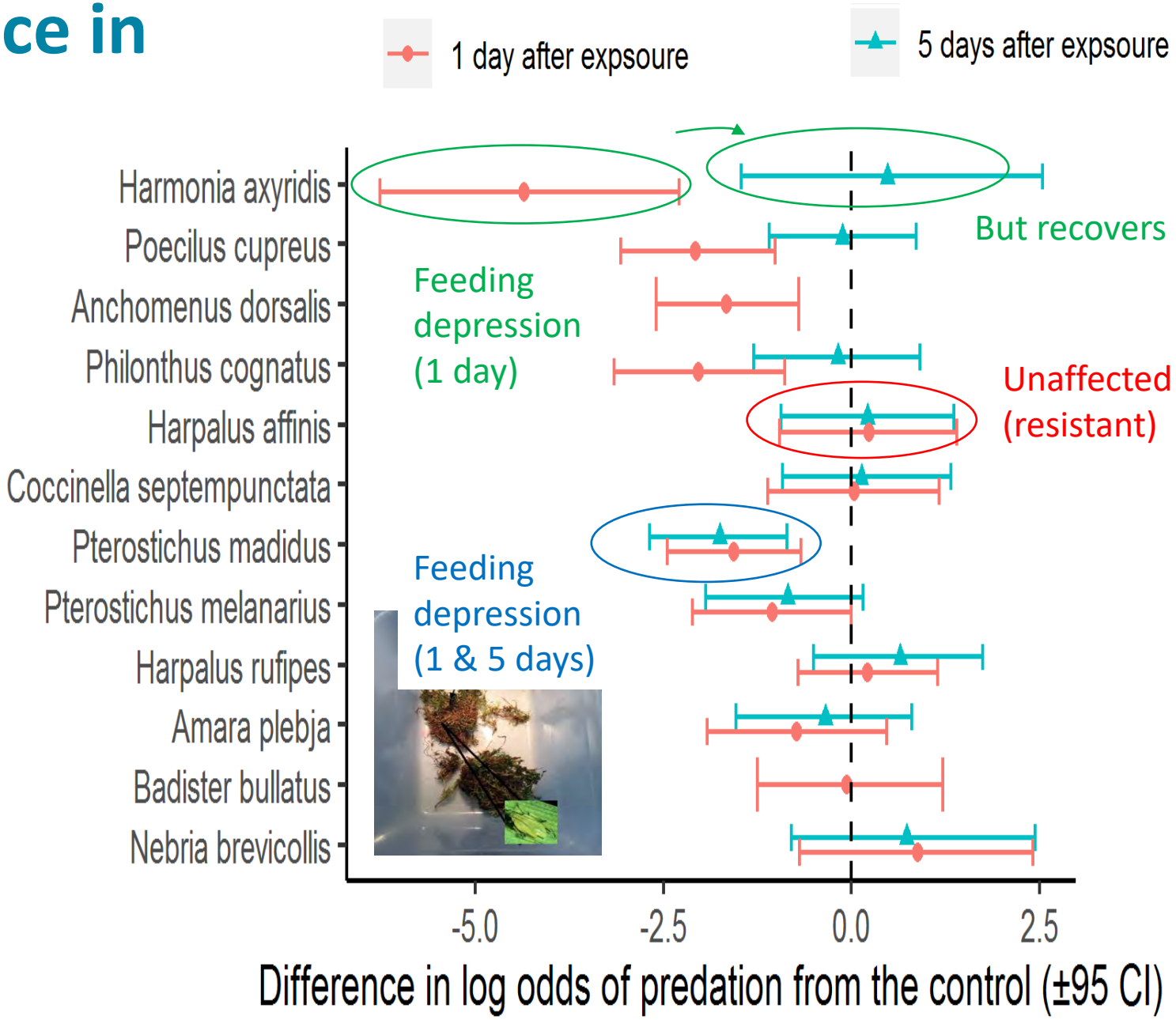

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The Hillesden Experiment

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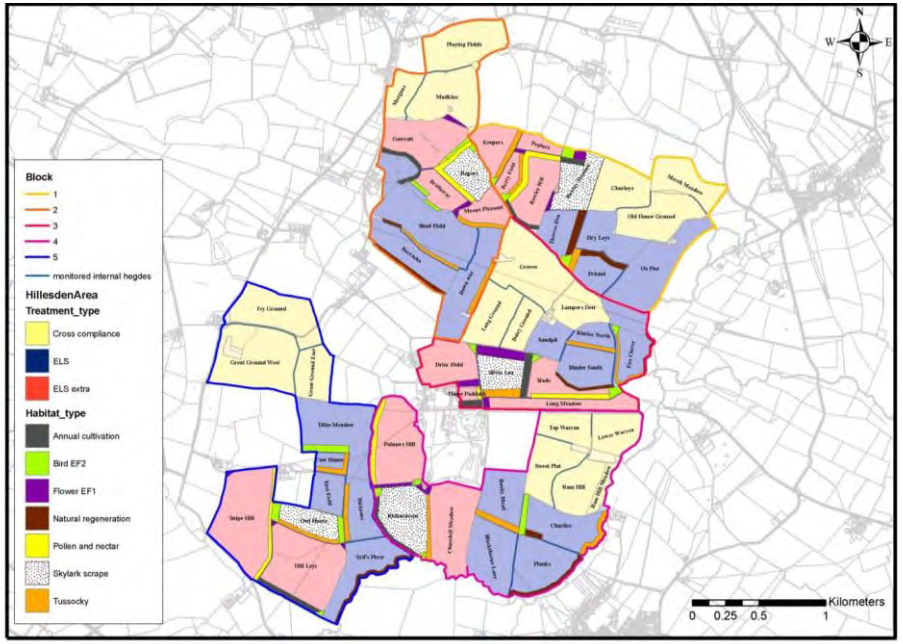
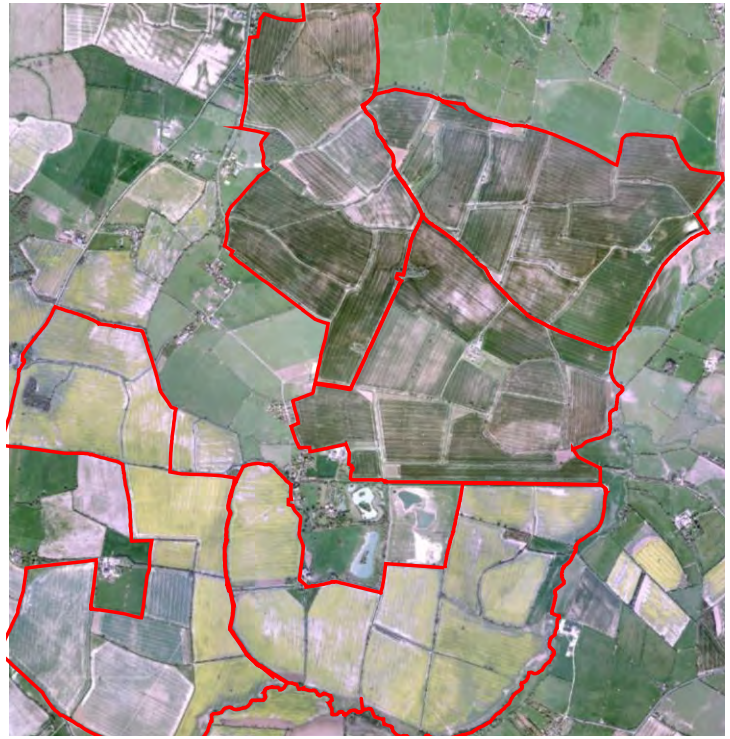
Department for Environment Food & Rural Affairs

NATURAL ENGLAND

The Hillesden farm platform

- 12-year study on a 1,000ha commercial arable farm
- Fifteen 50-60ha ‘farmlets’ = three treatments replicated FIVE times:
  - **Control business as usual - 0% land removed from production**
  - **3% land removed from arable production and turned to two wildlife habitats**
  - **8% land removed for six wildlife habitats**
- Precision yield data to target habitat creation in awkward/low yielding areas (margins & corners)





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https://agzeroplus.org.uk/hillesden

Using wildlife to support increased yields

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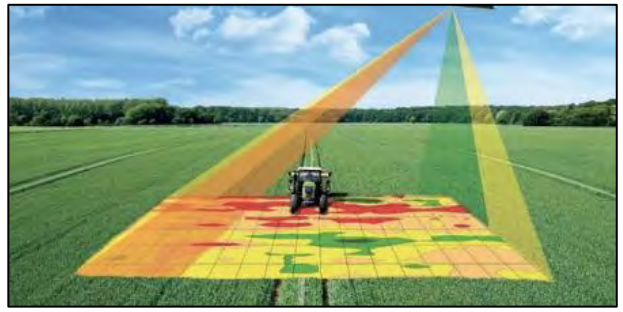
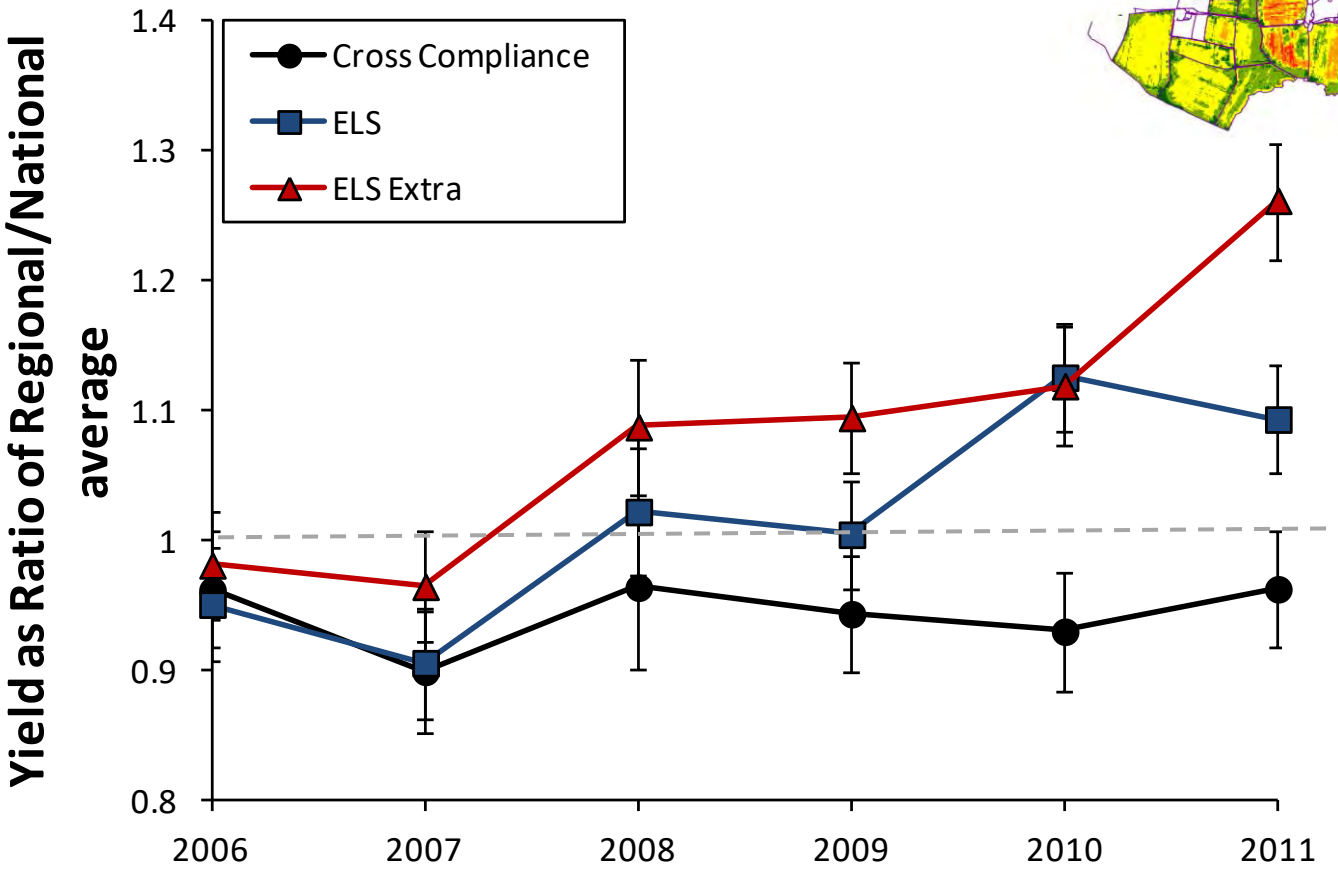
Yield mapping direct from harvesting machinery





Regional average yield

Pywell, R.B., Heard, M.S., Woodcock, B.A., Hinsley, S., Ridding, L., Nowakowski, M. & Bullock, J. (2015) Wildlife-Friendly Farming Increases Crop Yield: Evidence for Ecological Intensification. Proceedings of the Royal Society, Series B, 282, 20151740

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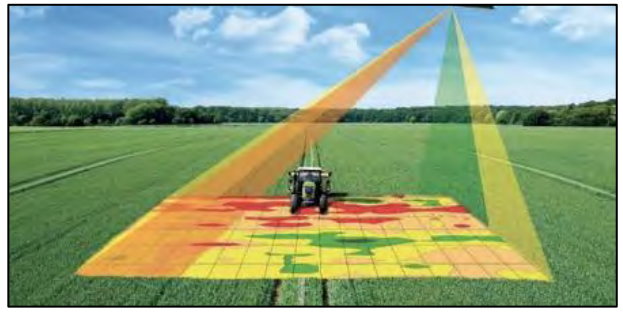

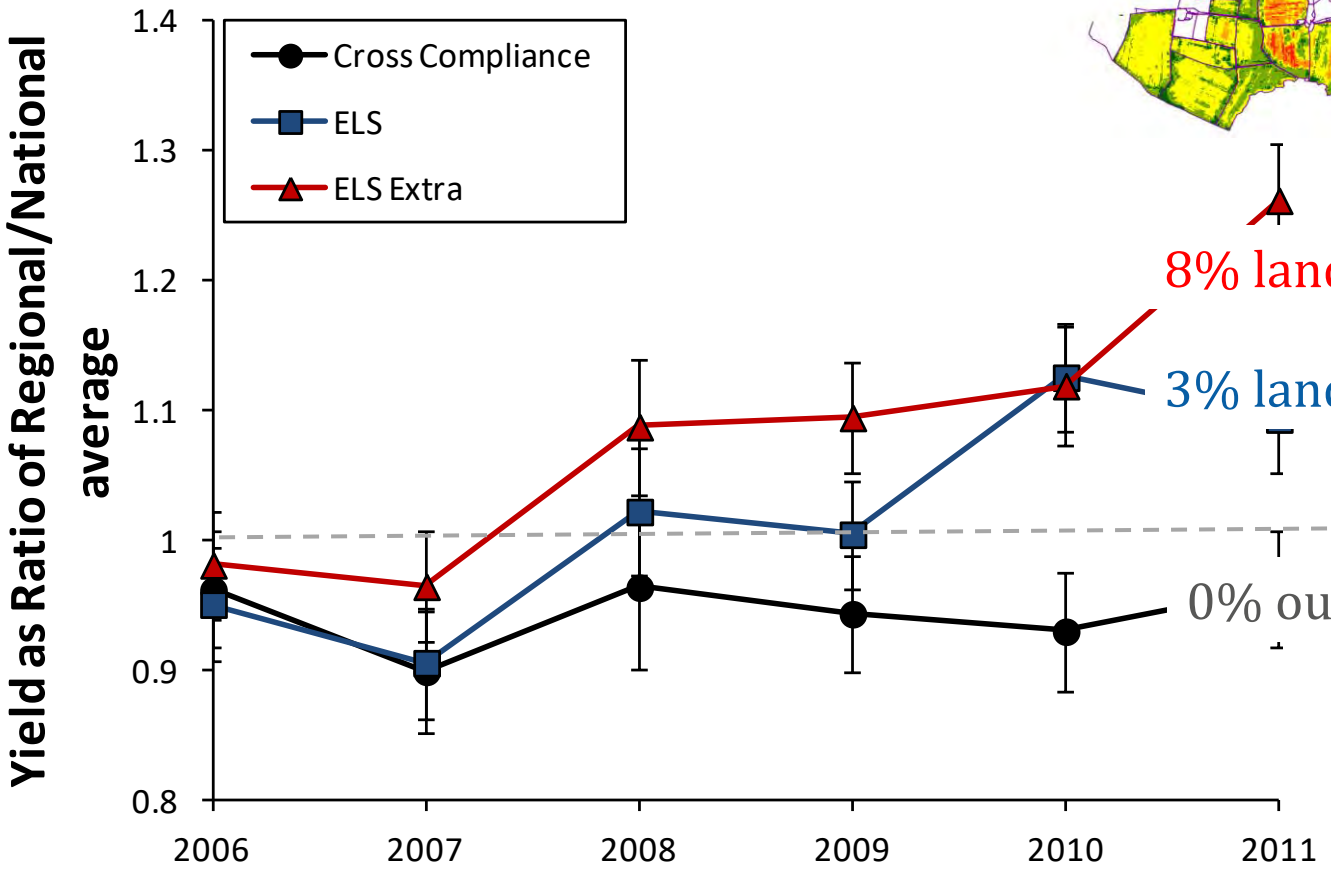

8% land out of production into wildlife habitats

3% land out of production into wildlife habitats

0% out of production

Pywell, R.B., Heard, M.S., Woodcock, B.A., Hinsley, S., Ridding, L., Nowakowski, M. & Bullock, J. (2015) Wildlife-Friendly Farming Increases Crop Yield: Evidence for Ecological Intensification. Proceedings of the Royal Society, Series B, 282, 20151740

Some of the first evidence of sustainable intensification

Wildlife-friendly farming increases crop yield: evidence for ecological intensification

Richard F. Pywell[1], Matthew S. Heard[1], Ben A. Woodcock[1], Shelley Hinsley[1], Lucy Ridding[1], Marek Nowakowski[2] and James M. Bullock[1]

[1]NERC Centre for Ecology and Hydrology, Wallingford OX10 8BB, UK
[2]Wildlife Farming Company, Bicester OX26 1UN, UK

PROCEEDINGS B

rspb.royalsocietypublishing.org

Research

Cite this article: Pywell RF, Heard MS, Woodcock BA, Hinsley S, Ridding L,

Yields increased over time in fields with wildlife habitat creation, despite removal of cropped land from field edges

The ASSIST Experiment

UK Centre for Ecology & Hydrology

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Can promoting natural pest control work in the real world?

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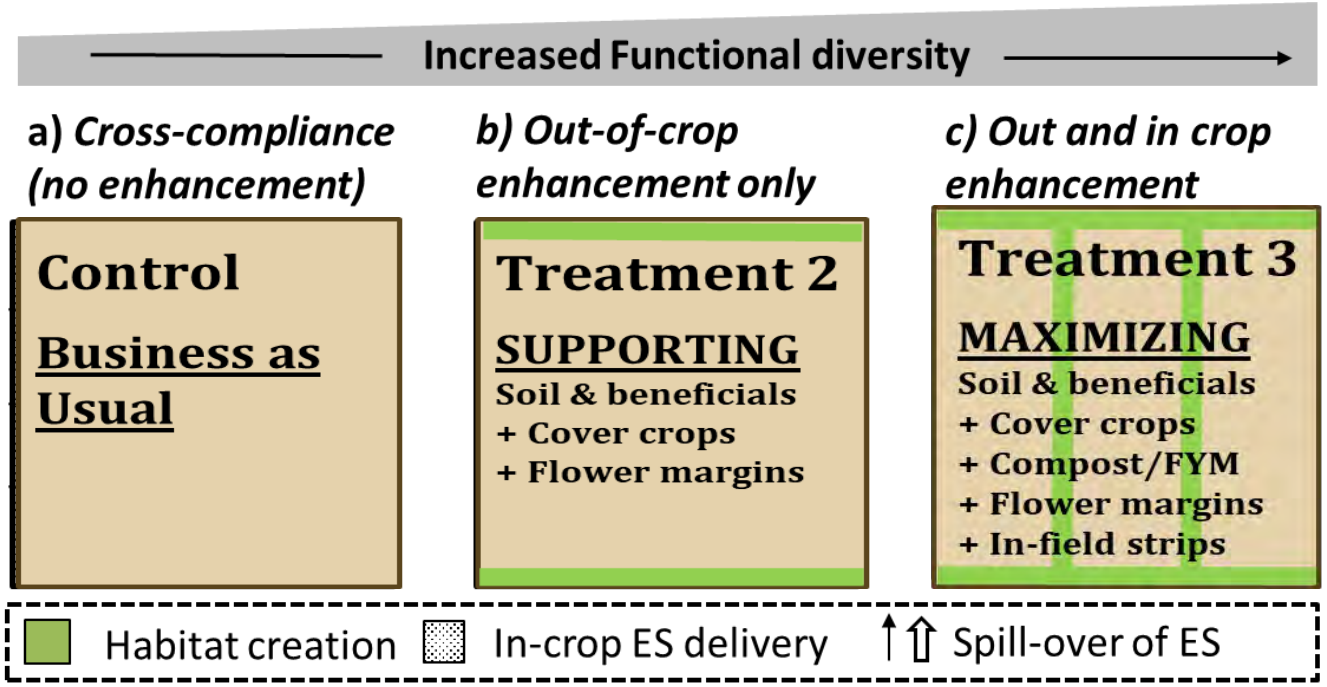
Multi-farm Experiment

- Network of 20 commercial arable farms
- Real-world test of eco-agriculture with agri-tech farming
- Opportunity for technology transfer & complementary research
- Similar experiment on grass farms

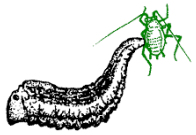
Maximising the spatial delivery of services

On each farm:

- Three fields
- On same soil
- Same crop rotation



To support pest control, pollination and in field delivery of soil biota

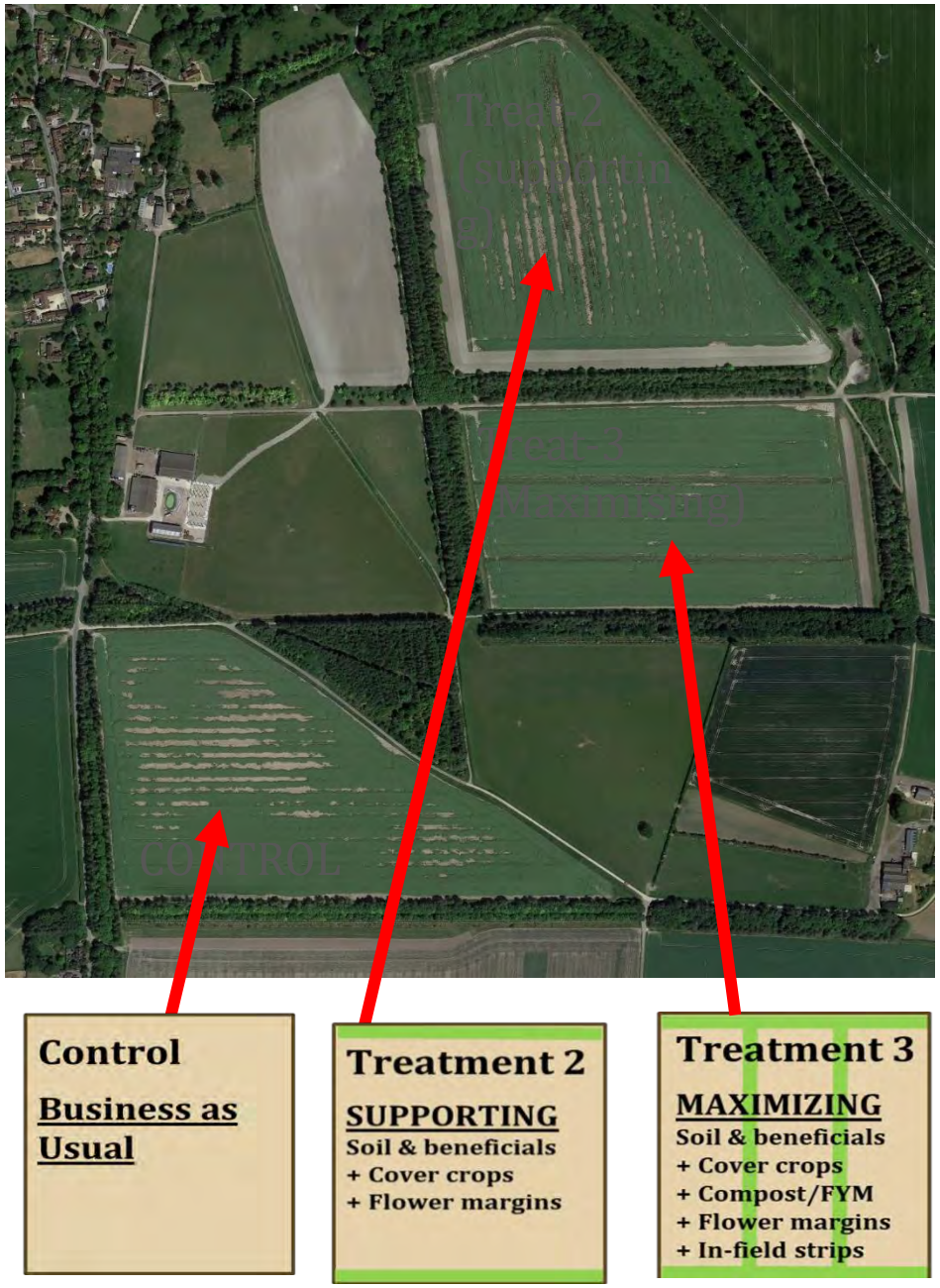


In-field strips working in with tramlines

- Strips programmed in with tramlines as headlands
- Farm ‘around’ the ends so no increase in corners

Impacts on yield

- 18 sites for 4 years
- Cereals and oilseed rape crops
- Sustainable management systems treatments 2 & 3 have positive effects on yield
- The more complex system (Treat.3) is on average better
- It takes time for biological systems to respond



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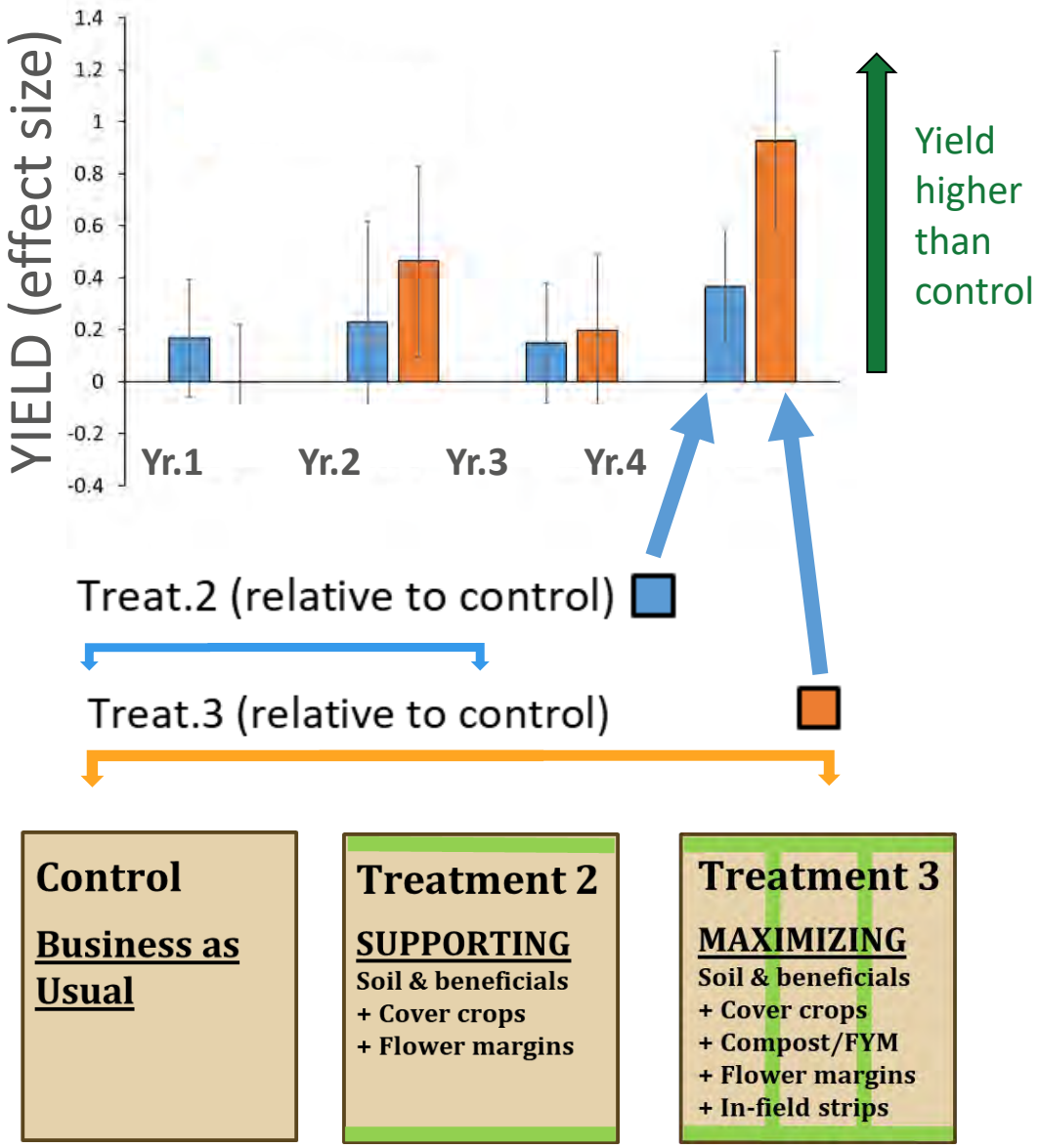
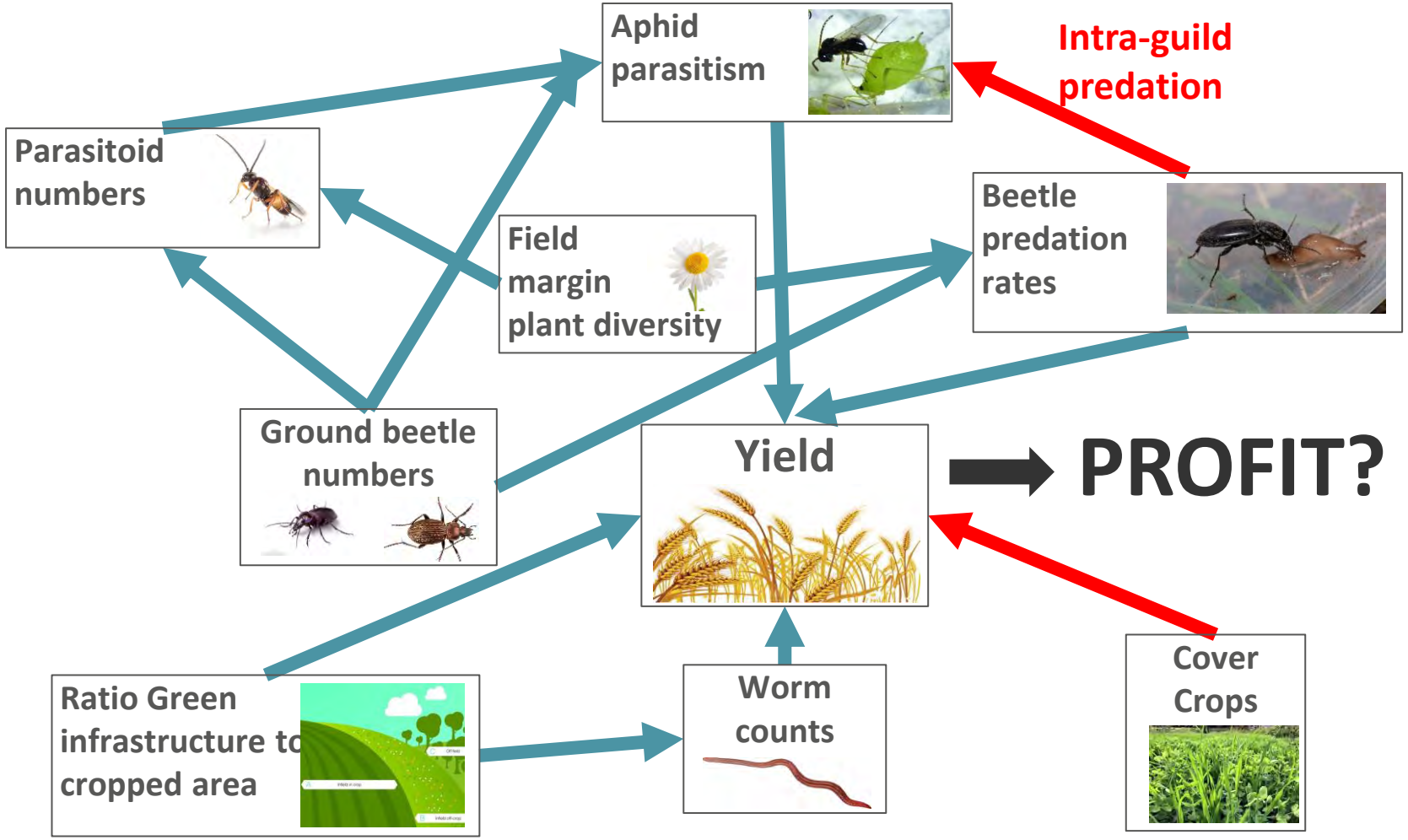
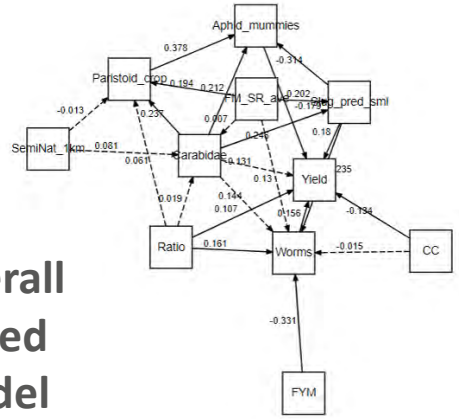


Preliminary results using Information Theoretic multi-model averaging based on plot level yield measures

Piecewise Structural Equation Modelling

Statistical approach looking at direct and indirect drivers of yield, including combined area of field margins and infield strips (green infrastructure)





Overall tested model

Negative effects

Positive effects

Decision Support Tools

AgZero+

Towards sustainable, climate-neutral farming

Natural Environment Research Council

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ROTHAMSTED RESEARCH

Biotechnology and Biological Sciences Research Council

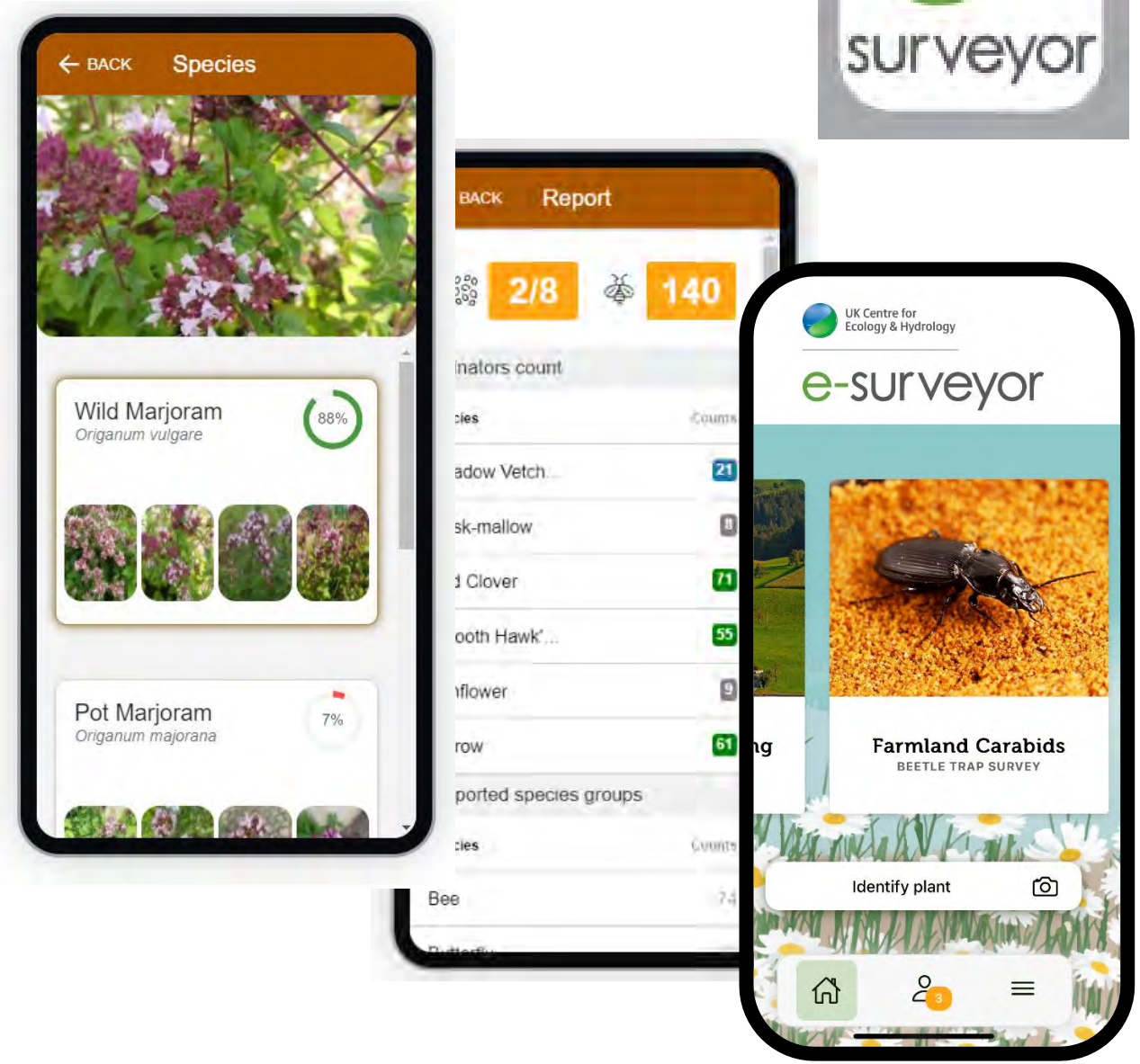
British Geological Survey

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

PML Plymouth Marine Laboratory

Practitioner biodiversity monitoring

- **Mobile App** to enable non-specialists to monitor habitats
- **AI image** recognition for automatic ID of plant species and habitats from photos
- **Contextual information** to improve accuracy
- Survey function and data provided on **associated beneficial insects**
- **In development…..<u>Ground beetles (IPM),</u>** Moths, Worms (soil health)



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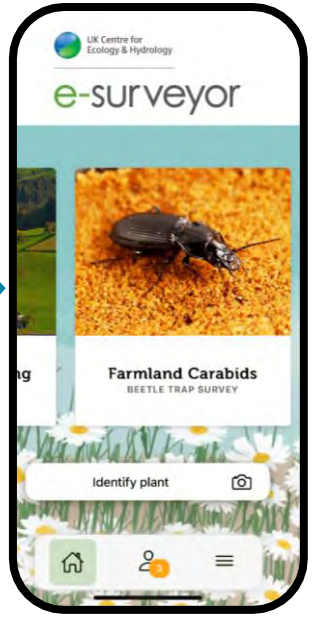
AgZero+

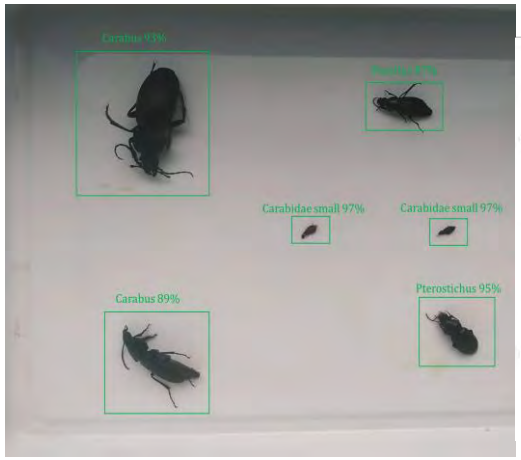
Developing new tools to support IPM

Natural pest control is a 'black box' - Is management working to increase pest control?

Pitfall trapping



AI image recognition of pitfall trap contents (~90% accurate)



Test set accuracy: 86%

	precision	recall	f1-score	support
abax_parallelepipedus	0.93	0.76	0.85	18
amara_aenea	0.80	0.86	0.86	16
amara_aulica	1.00	0.58	0.74	12
amara_bifrons	0.60	0.75	0.67	4
amara_consecular_communis	0.57	1.00	0.73	4
amara_ovata_cisilata	0.82	0.90	0.86	18
amara_plebeja	1.00	0.43	0.60	7
anchomenus_dorsalis	0.94	0.89	0.92	18
background	0.98	0.93	0.95	51
bembidion_lamprosi_properans	0.50	0.56	0.50	9
bembidion_obtusum	0.75	1.00	0.86	3
bembidion_quadrimaculatum	1.00	0.50	0.67	4
brachinus_crepitans	0.82	0.50	0.86	16
calathus_fuscipes	0.83	0.83	0.83	6
calathus_melanocephalus	0.86	1.00	0.92	6
carabus_monilis	1.00	0.50	0.67	2
carabus_nemoralis	0.91	0.83	0.87	12
carabus_problematicus	0.87	0.76	0.81	17
carabus_violaceus	0.69	0.79	0.73	14
carbidae_smaller_than_5mm	0.95	0.80	0.82	48
harpalus_affinis	0.83	0.67	0.74	15
harpalus_rufipes	1.00	1.00	1.00	10
harpalus_tardus	1.00	1.00	1.00	2
larvae	1.00	1.00	1.00	9
leistus	0.91	0.91	0.91	11
leistus_spinibarbis	0.89	0.80	0.84	10
loricera_pilicornis	0.97	0.97	0.97	38
nebria_brevicollis_salina	0.79	0.88	0.84	26
notiophilus_biguttatus	0.83	1.00	0.91	18
notiophilus_substriatus	0.88	0.75	0.80	8
ophonus	0.80	1.00	0.89	4
other_classes	0.90	0.06	0.02	45
other_coleoptera	0.87	0.81	0.84	16
poecilus_cupreus_versicolor	0.81	1.00	0.90	13
pterostichus_madidus	0.90	0.90	0.85	31
pterostichus_melanarius	0.73	0.80	0.76	10
pterostichus_niger	0.64	0.88	0.74	8
pterostichus_strenuus	0.56	0.71	0.63	7
pterostichus_vernalis	1.00	0.81	0.91	8
accuracy			0.86	560
macro avg	0.81	0.81	0.83	560
weighted avg	0.87	0.86	0.86	560

- Abundance of predators
- How effective are they
- Long-term goal is to relate these to thresholds for spraying

https://agzeroplus.org.uk/agzeroplus-tools

Practical guides to sustainable farming

UK Centre for Ecology & Hydrology

7 videos 215 views Updated today

Play all

Shuffle

Video series exploring ways that farmers can reduce their carbon footprint, make best use of pesticides and help bring wildlife back to their farms.

Part of the AgZero+ programme: https://agzeroplus.org.uk/

1 

Introduction: A practical guide to sustainable farming

UK Centre for Ecology & Hydrology • 200 views • 4 months ago

2 

In-field wildflower strips and hedges - a practical guide to sustainable farming

UK Centre for Ecology & Hydrology • 256 views • 3 months ago

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Feeding farmland birds in winter - a practical guide to sustainable farming | AgZero+

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E-Planner: Enhancing farm environmental decisions | AgZero+

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E-Surveyor: Monitoring farmland biodiversity

UK Centre for Ecology & Hydrology • 196 views • 1 month ago

6 

Encouraging beneficial insects on your farm

UK Centre for Ecology & Hydrology • 171 views • 4 weeks ago

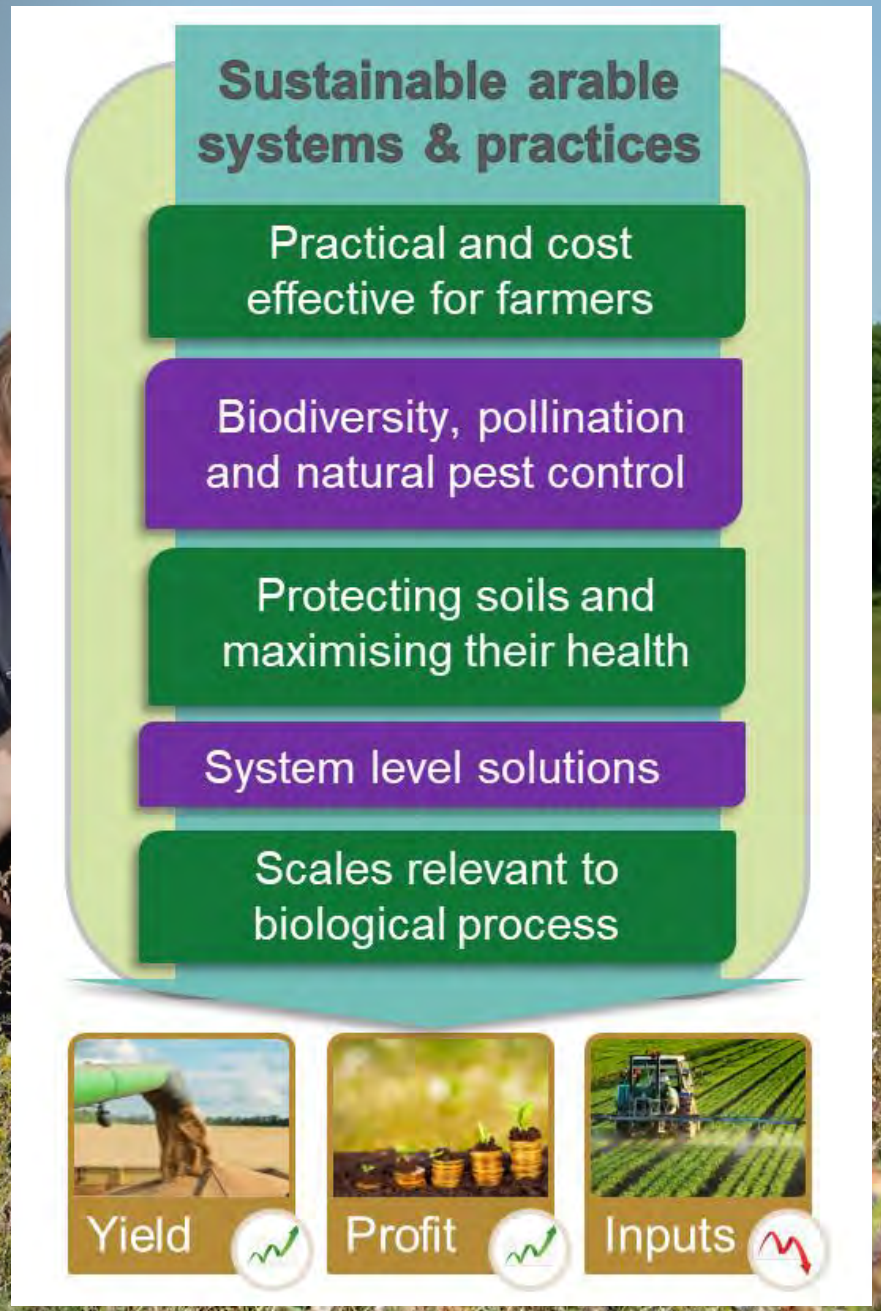
7 

Soil carbon on your farm | AgZero+

UK Centre for Ecology & Hydrology • 4 views • 10 hours ago

Conclusions

1. Mechanistic experiments show it is possible to increase natural pest control
2. This is important for increasing resilience of farming systems
3. Co-design with farmers resulted in practical approaches to achieving this (strips = SFI)
4. Multi-site experiments on commercial farms show yield benefits in the real world
5. AI-driven decision support tools (with training & advice) will support future IPM



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Special thanks to all the ASSIST farmers and the UKCEH and RRes field teams

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e-surveyor https://www.ceh.ac.uk/e-surveyor

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