Soil Association

# Ecological Innovation – Challenges and Opportunities For UK Agriculture

Prof Tim Benton, UK champion for Global Food Security

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The Organic Milk Cooperative
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*'The blasted badgers have moved the goalposts again!'*

# Ecological innovation - challenges and opportunities for UK agriculture


Tim Benton

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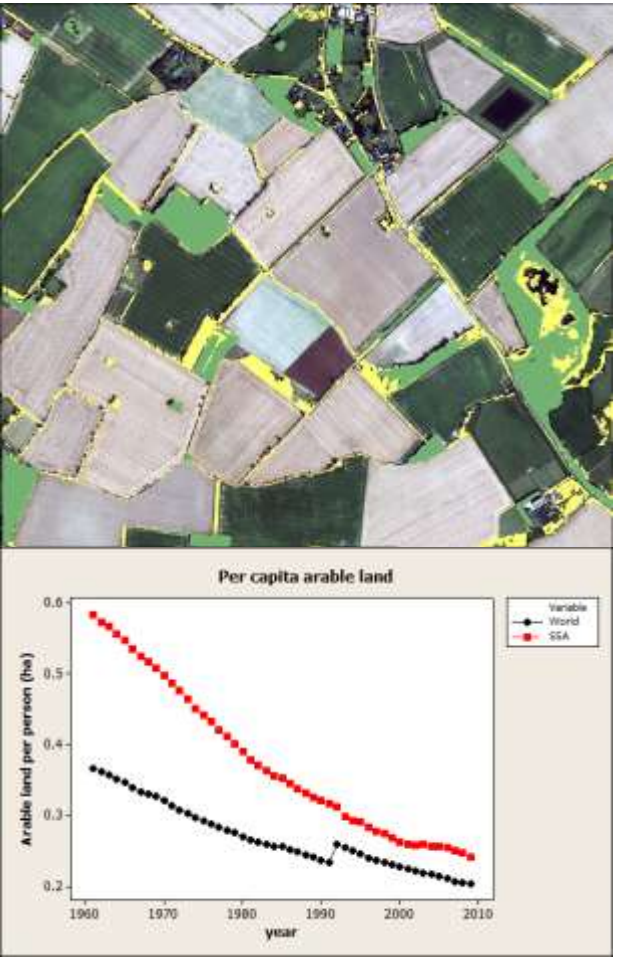
*@timgbenton*

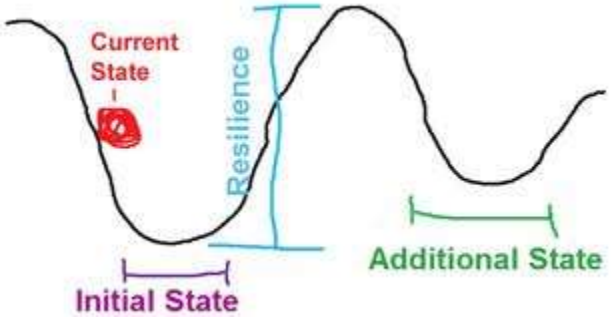
# Competition for land




- Competition for land leads to intensification
- If demand is growing and the available land is shrinking more is required per unit area (= intensification)
- This needs to be sustainable (=sustainable intensification)

http://www.worldbank.org/

# Resilience and sustainability




tems maintain their integrity
:t to disturbance (Holling 1973)

:y is the capacity to endure

- Brundtland: "Sustainable development is development that meets the needs of the present
: compromising the ability of future
:ions to meet their own needs".

# Natural capital is finite and provides services

Other capital inputs

| Ecosystem processes/ Intermediate services | Final ecosystem services | Good(s)* |
|---|---|---|
| Primary production | Crops, livestock, fish | Food |
| Water cycling | Trees, standing vegetation, peat | Fibre |
| Soil formation | Water supply | Energy |
| Nutrient cycling | Climate regulation | Drinking water |
| Decomposition | Disease & pest regulation | Natural medicine |
| Weathering | Detoxificaton & purification in air, soils & water | Recreation/Tourism |
| Ecological interactions | Pollination | Pollution/noise control |
| Evolutionary processes | Hazard regulation | Disease/pest control |
| Undiscovered | Noise regulation | Equable climate |
| | Wild species diversity | Flood control |
| | Environmental settings | Erosion control |
| | Undiscovered services | Aesthetic/Inspiration |
| | | Spiritual/Religious |
| | | Undiscovered |

VALUES

Millennium Ecosystem Assessment categories:
- Cultural
- Provisioning
- Regulating
- Supporting

UK National ecosystem assessment 2011

# Natural capital subsidises the landuse economy

- Unaccounted degradation of natural capital
- What do we know about long term consequences?

BARCLAYS

Barclays Bank
54 Lombard Street
London
EC30 3AH

Sort Code: 20-00-00

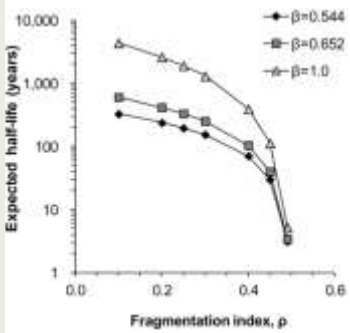
Account Number: 70000085

Account Name: Capital Westland

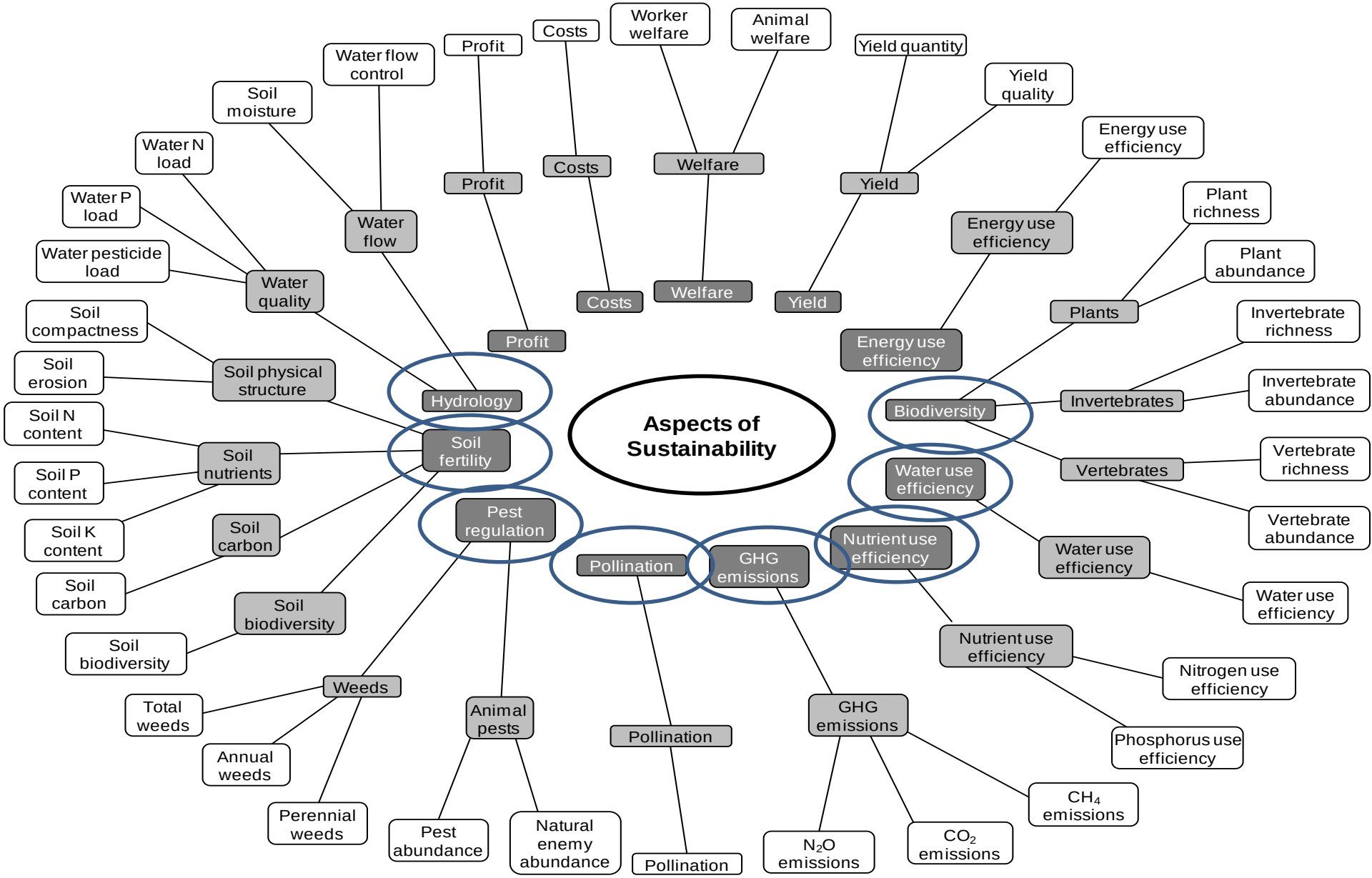
1st October — 30th April

| Credit: | | | |
|---|---|---|---|
| October | £17,258.25 | February | £11,581.90 |
| November | £17,815.55 | March | £10,126.00 |
| December | £5,821.67 | April | £28,651.00 |
| January | £3,432.87 | | |
| Total: | | | £94,693.24 |

Extinction risk as a non-linear function of large scale habitat fragmentation: what happens on your farm may depend on the neighbours



# Land use impacts on many axes: many are subsidised




Quantitative review of studies assessing “sustainable agriculture” (German, Thompson & Benton, in prep)

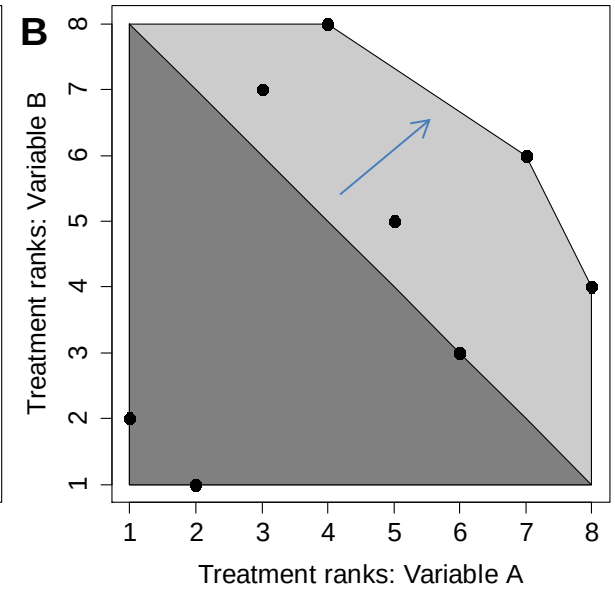
Variable 2

| Variable 1 | Soil physical structure | Water flow | Soil biodiversity | Soil carbon | Soil nutrients | Water quality | Yield | Water use efficiency | Nutrient use efficiency | Plants | Invertebrates | Vertebrates | Pollination | Animal pests | Weeds | GHG emissions | Energy use efficiency | Welfare | Costs | Profit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil physical structure | | 0.54 | 0.31 | 0.21 | 0.33 | 0.54 | 0.41 | 0.72 | - | 0.65 | - | - | - | - | 0.96 | 1.00 | -1.00 | - | -0.35 | -0.78 |
| Water flow | | | 0.85 | 0.89 | 0.33 | 0.50 | 0.23 | 0.74 | 0.44 | 0.05 | - | - | - | 0.24 | -0.38 | 1.00 | - | - | 0.81 | -0.53 |
| Soil biodiversity | | | | 0.98 | 0.81 | 0.25 | 0.30 | 1.00 | 0.41 | 0.60 | 0.65 | 1.00 | - | - | - | - | 0.80 | - | 1.00 | 1.00 |
| Soil carbon | | | | | 0.64 | 0.30 | 0.61 | 0.73 | 0.66 | -0.05 | 0.80 | - | - | 1.00 | -1.00 | -1.00 | 0.70 | -0.87 | -0.38 | 0.65 |
| Soil nutrients | | | | | | -0.16 | 0.47 | -0.03 | 0.75 | 0.56 | 0.32 | - | - | 0.05 | -1.00 | -0.02 | 0.28 | 0.00 | 0.22 | -0.03 |
| Water quality | | | | | | | -0.74 | 0.87 | 1.00 | 0.99 | 1.00 | - | - | 1.00 | - | -0.75 | 0.73 | 0.70 | 0.43 | 0.04 |
| Yield | | | | | | | | 0.86 | 0.54 | -0.60 | -0.43 | -0.17 | 0.40 | 0.27 | 0.95 | 0.13 | -0.71 | 0.47 | -0.52 | 0.67 |
| Water use efficiency | | | | | | | | | 0.59 | - | - | - | - | 1.00 | - | - | - | - | 0.06 | 0.42 |
| Nutrient use efficiency | | | | | | | | | | - | - | - | - | 1.00 | - | - | 1.00 | 1.00 | -0.87 | 0.00 |
| Plants | | | | | | | | | | | 0.40 | 0.86 | - | 0.69 | - | 0.00 | 1.00 | 0.50 | 1.00 | 0.81 |
| Invertebrates | | | | | | | | | | | | 0.42 | 0.97 | 0.61 | - | - | 1.00 | - | 1.00 | 0.49 |
| Vertebrates | | | | | | | | | | | | | - | 0.82 | - | - | - | - | - | 0.87 |
| Pollination | | | | | | | | | | | | | | 0.40 | - | - | - | - | - | - |
| Animal pests | | | | | | | | | | | | | | | - | - | - | - | -1.00 | -1.00 |
| Weeds | | | | | | | | | | | | | | | | - | - | - | - | - |
| GHG emissions | | | | | | | | | | | | | | | | | 0.12 | -0.70 | 1.00 | -1.00 |
| rgy use efficiency | | | | | | | | | | | | | | | | | | 0.15 | 0.22 | 0.79 |
| Welfare | | | | | | | | | | | | | | | | | | | -0.96 | 0.35 |
| Costs | | | | | | | | | | | | | | | | | | | | 0.29 |
| Profit | | | | | | | | | | | | | | | | | | | | |

**Table 1. Matrix of mean pairwise correlation coefficients** Weighted averages of the correlation coefficients for each pair of response variables, calculated across all studies. Cell colour scaled for each measure to aid visual interpretation.

Different aspects of sustainability may trade-off

# Reducing trade-offs




Variable 2

| Variable 1 | Soil physical structure | Water flow | Soil biodiversity | Soil carbon | Soil nutrients | Water quality | Yield | Water use efficiency | Nutrient use efficiency | Plants | Invertebrates | Vertebrates | Pollination | Animal pests | Weeds | GHG emissions | Energy use efficiency | Welfare | Costs | Profit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil physical structure | | 0.54 | 0.31 | 0.21 | 0.33 | 0.54 | 0.41 | 0.72 | - | 0.65 | - | - | - | - | 0.96 | 1.00 | -1.00 | - | -0.35 | -0.78 |
| Water flow | 0.91 | | 0.85 | 0.89 | 0.33 | 0.50 | 0.23 | 0.74 | 0.44 | 0.05 | - | - | - | 0.24 | -0.38 | 1.00 | - | - | 0.81 | -0.53 |
| Soil biodiversity | 0.86 | 0.95 | | 0.98 | 0.81 | 0.25 | 0.30 | 1.00 | 0.41 | 0.60 | 0.65 | 1.00 | - | - | - | - | 0.80 | - | 1.00 | 1.00 |
| Soil carbon | 0.87 | 0.97 | 0.98 | | 0.64 | 0.30 | 0.61 | 0.73 | 0.66 | -0.05 | 0.80 | - | - | 1.00 | -1.00 | -1.00 | 0.70 | -0.87 | -0.38 | 0.65 |
| Soil nutrients | 0.92 | 0.89 | 0.98 | 0.95 | | -0.16 | 0.47 | -0.03 | 0.75 | 0.56 | 0.32 | - | - | 0.05 | -1.00 | -0.02 | 0.28 | 0.00 | 0.22 | -0.03 |
| Water quality | 0.95 | 0.75 | 0.95 | 0.81 | 0.92 | | -0.74 | 0.87 | 1.00 | 0.99 | 1.00 | - | - | 1.00 | - | -0.75 | 0.73 | 0.70 | 0.43 | 0.04 |
| Yield | 0.88 | 0.85 | 0.84 | 0.92 | 0.94 | 0.57 | | 0.86 | 0.54 | -0.60 | -0.43 | -0.17 | 0.40 | 0.27 | 0.95 | 0.13 | -0.71 | 0.47 | -0.52 | 0.67 |
| Water use efficiency | 0.95 | 0.95 | 1.00 | 0.91 | 0.86 | 1.00 | 0.98 | | 0.59 | - | - | - | - | 1.00 | - | - | - | - | 0.06 | 0.42 |
| Nutrient use efficiency | - | 1.00 | 0.91 | 0.91 | 0.95 | 1.00 | 0.87 | 0.95 | | - | - | - | - | 1.00 | - | - | 1.00 | 1.00 | -0.87 | 0.00 |
| Plants | 0.98 | 0.73 | 1.00 | 0.89 | 0.97 | 1.00 | 0.48 | - | - | | 0.40 | 0.86 | - | 0.69 | - | 0.00 | 1.00 | 0.50 | 1.00 | 0.81 |
| Invertebrates | - | - | 0.79 | 1.00 | 0.67 | 1.00 | 0.81 | - | - | 0.90 | | 0.42 | 0.97 | 0.61 | - | - | 1.00 | - | 1.00 | 0.49 |
| Vertebrates | - | - | 1.00 | - | - | - | 0.79 | - | - | 1.00 | 0.92 | | - | 0.82 | - | - | - | - | - | 0.87 |
| Pollination | - | - | - | - | - | - | 1.00 | - | - | - | 1.00 | - | | 0.40 | - | - | - | - | - | - |
| Animal pests | - | 0.89 | - | 1.00 | 0.73 | 1.00 | 0.88 | 1.00 | 1.00 | 1.00 | 0.89 | 1.00 | 0.78 | | - | - | - | - | -1.00 | -1.00 |
| Weeds | 1.00 | 0.81 | - | 0.00 | 0.20 | - | 0.98 | - | - | - | - | - | - | - | | - | - | - | - | - |
| GHG emissions | 1.00 | 1.00 | - | 0.00 | 0.70 | 0.29 | 0.59 | - | - | 0.63 | - | - | - | - | - | | 0.12 | -0.70 | 1.00 | -1.00 |
| Energy use efficiency | 0.00 | - | 0.89 | 0.90 | 0.81 | 0.95 | 0.61 | - | 1.00 | 1.00 | 1.00 | - | - | - | - | 0.89 | | 0.15 | 0.22 | 0.79 |
| Welfare | - | - | - | 0.50 | - | 0.94 | 0.97 | - | 1.00 | 1.00 | - | - | - | - | - | 0.44 | 0.88 | | -0.96 | 0.35 |
| Costs | 0.67 | 1.00 | 1.00 | 0.38 | 0.86 | 0.92 | 0.50 | 0.91 | 0.50 | 1.00 | 1.00 | - | - | 0.00 | - | 1.00 | 0.59 | 0.62 | | 0.29 |
| Profit | 0.30 | 0.69 | 1.00 | 0.84 | 0.96 | 0.92 | 0.94 | 0.88 | 0.82 | 0.86 | 0.95 | 1.00 | - | 0.00 | - | 0.00 | 0.93 | 0.92 | 0.78 | |

# “Sustainable landuse” needs…

- Management of farming’s impacts within plots/fields
- management of land to maintain other services

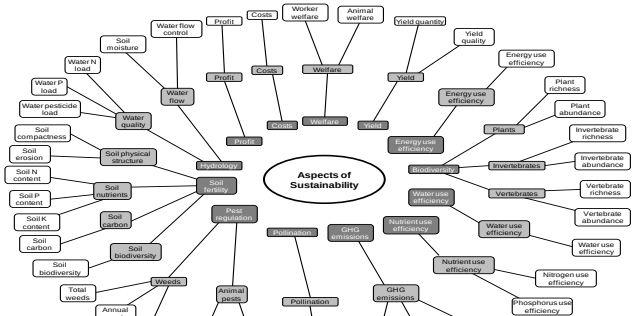
Sustainable agricultural landscapes require landscape planning: many services depend on the amount, quality and configuration of non-cropped habitat

# Context specificity and scale

ch questions: how does “what is
according to location and scale?

bility and certification

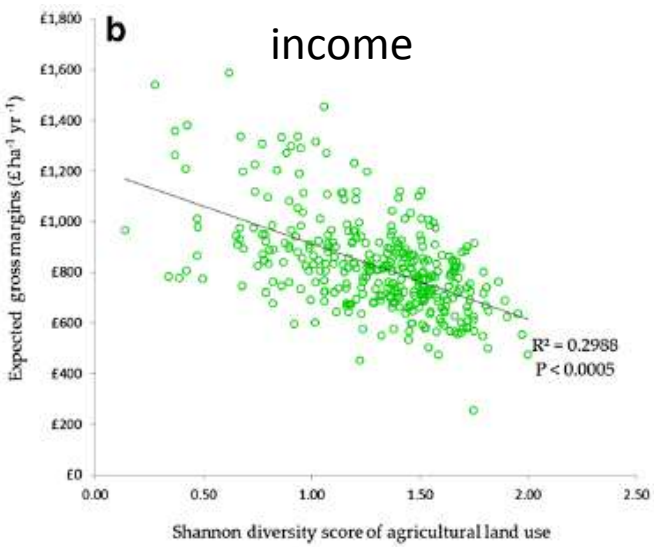
ice and farmer peer-to-peer

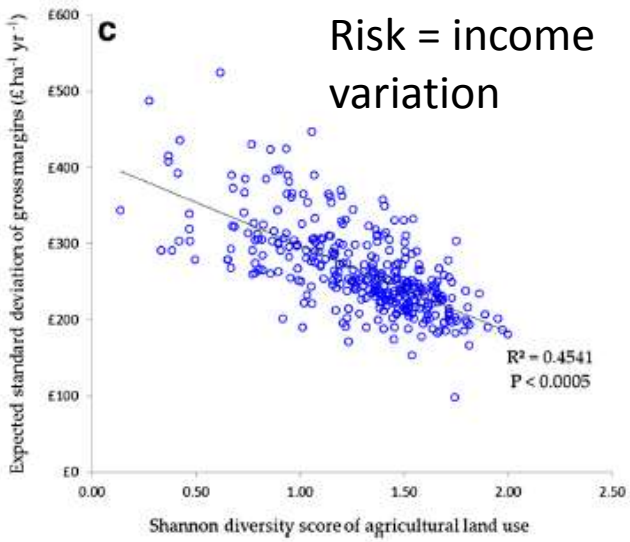


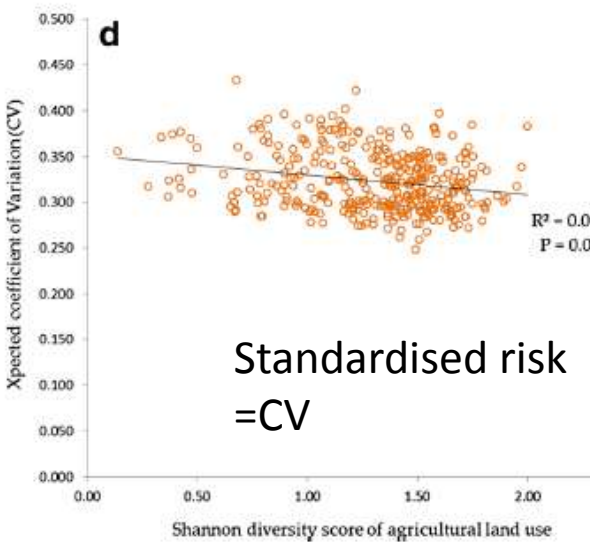
# Building resilience by portfolio management

The only thing that is certain about the future is that it will be more uncertain than now

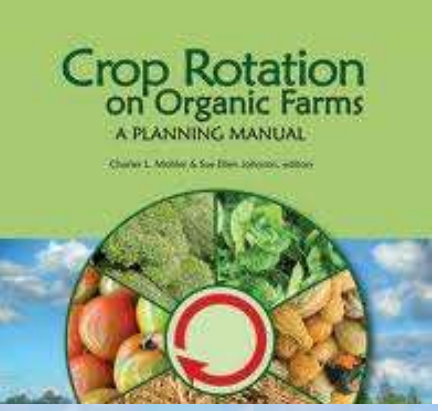
- Diverse cropping systems give lower fluctuations in income
- Diversity creates landscape heterogeneity which is associated with increased biodiversity



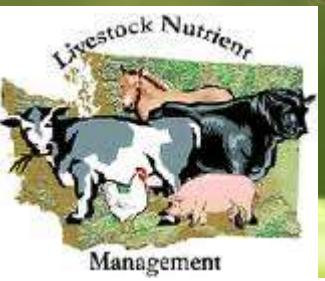




Abson et al 2013 Agriculture and food security



# Ecological innovation

- If intensification is to be sustainable we need greater ecological innovation
- Need new science and new ways of understanding ES and NC
  - UK world leading
- Organic practices *aim* to enhance ES
  - Scope to understand better
  - Scope to transfer to other farming systems
  - Organic farming can improve its sustainability



# Thank you!

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