CAPER 2013
Committee on Air Pollution Effects Research

ROTHAMSTED RESEARCH

Developing sustainable farming systems by valuing ecosystem services

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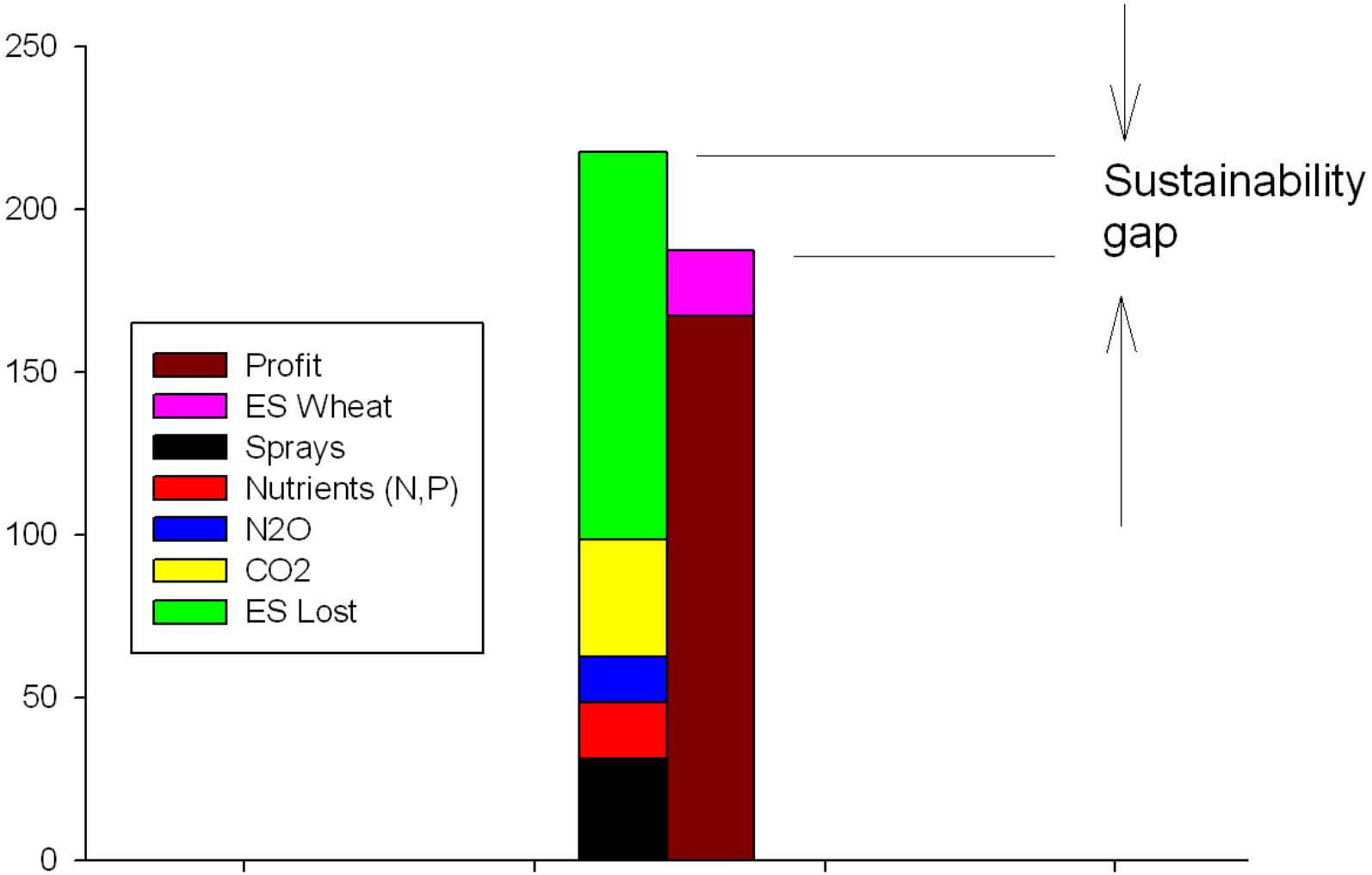
Rothamsted research

BBSRC bioscience for the future

What is sustainability?



Quantifying sustainability

- Common unit needed. Used a financial assessment to begin with based on Total Factor Productivity (TFP)
- Includes both business *and e*nvironmental costs
- Used to analyse the overall sustainability of wheat on Broadbalk and several different commodities from ‘real’ farming systems

Total Factor Productivity (TFP)

- Ratio of Outputs to Costs in common units, i.e. £ or euro
- There may be multiple outputs (straw, grain, wool, meat, milk, etc.)
- Costs include environmental costs, i.e. externalities
- TFP>1 implies sustainability

(Glendining et al., 2009, *Agricultural Systems* **99**, 117-125.)

Data sources for commodities

- Life Cycle Analyses

  Williams et al Report to Defra, 2006
- Agricultural Almanacs for economic data

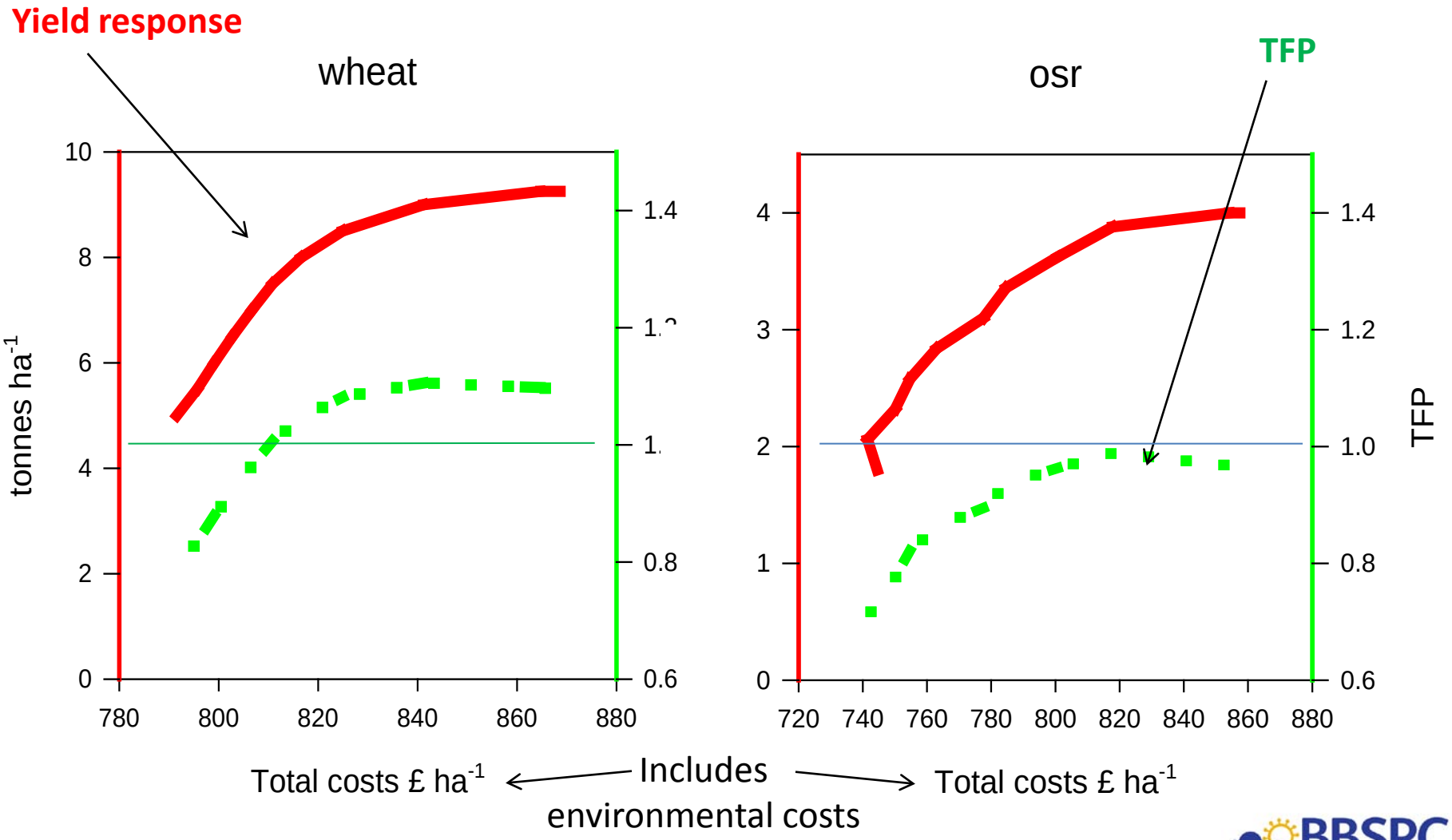
  Nix, 2005
- Environmental burdens of nutrients, GHG, Sprays

  Pretty et al , Agricultural Systems 2000, Environmental Science & Technology 2003
- Land valuation through Ecosystem Services (ES)

  Costanza et al., Nature, 1997
- Computer simulation models and tools:

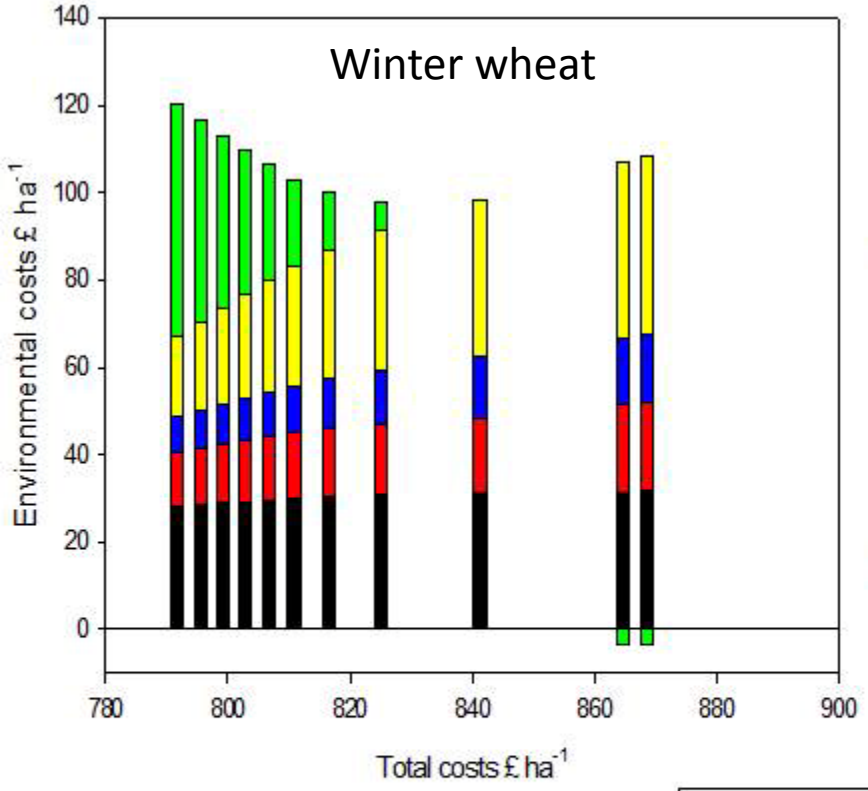
  SUNDIAL, WDM, Quad-Mod

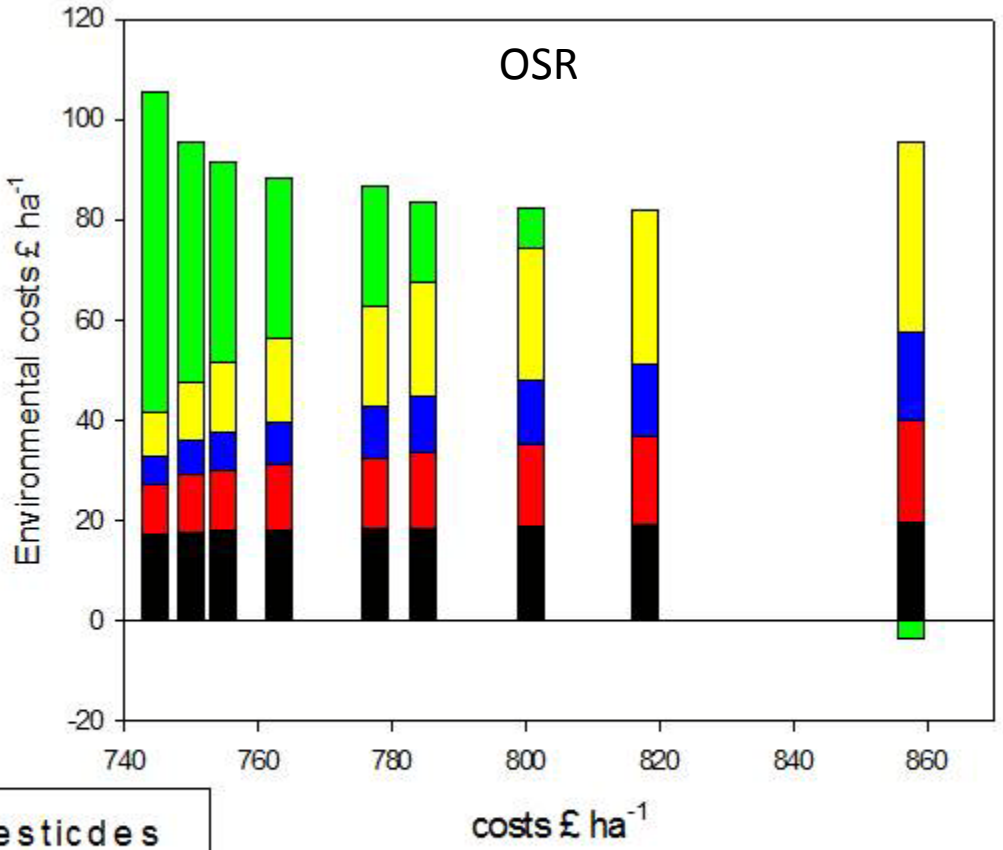
Wheat and oilseed rape, 2006 data

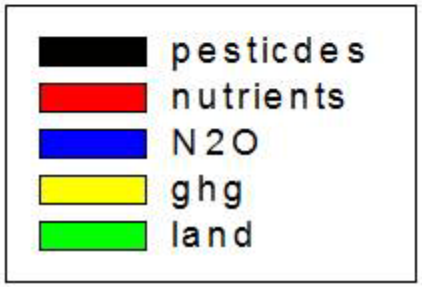


Breakdown of environmental costs and burdens for arable crops

ROTHAMSTED RESEARCH







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Beef and sheep farming

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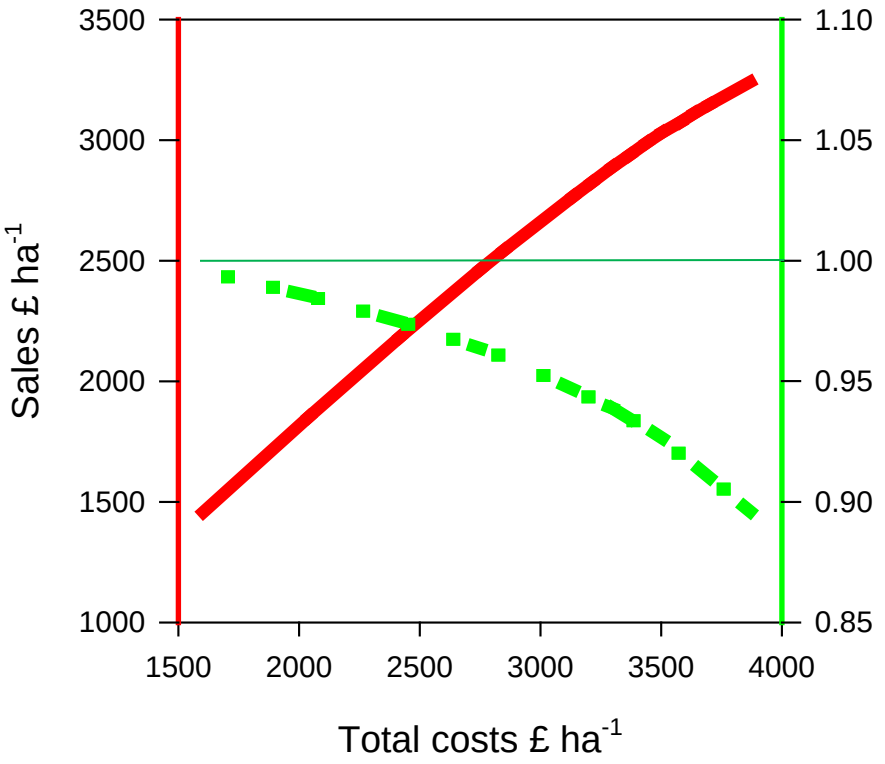
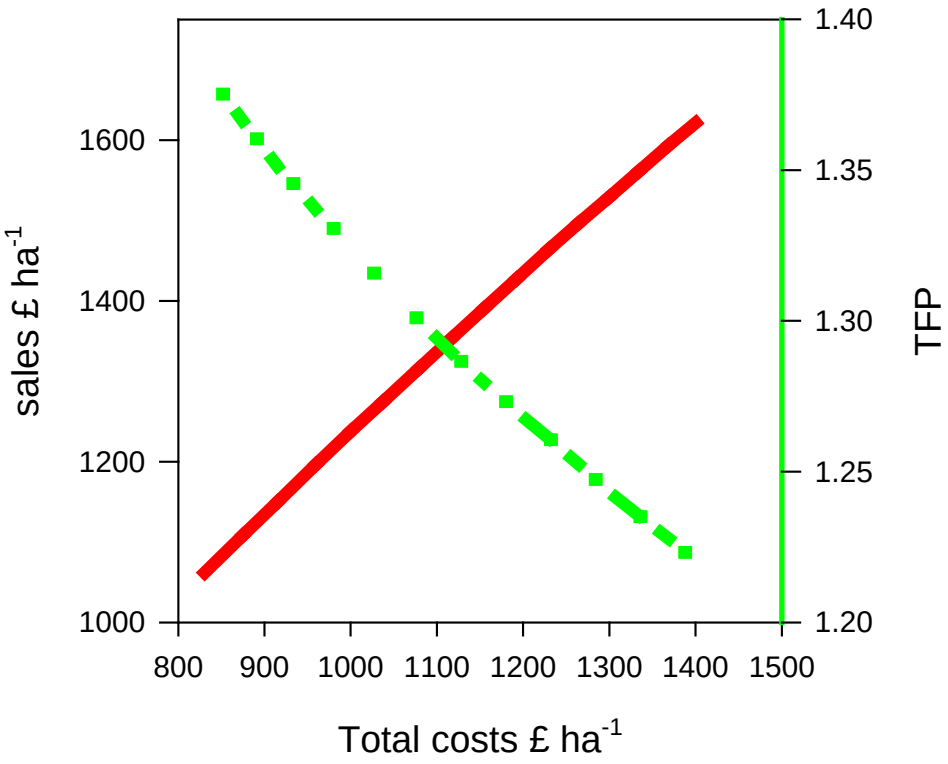
Grazed 18 month Beef



3 month finishing grazed lambs



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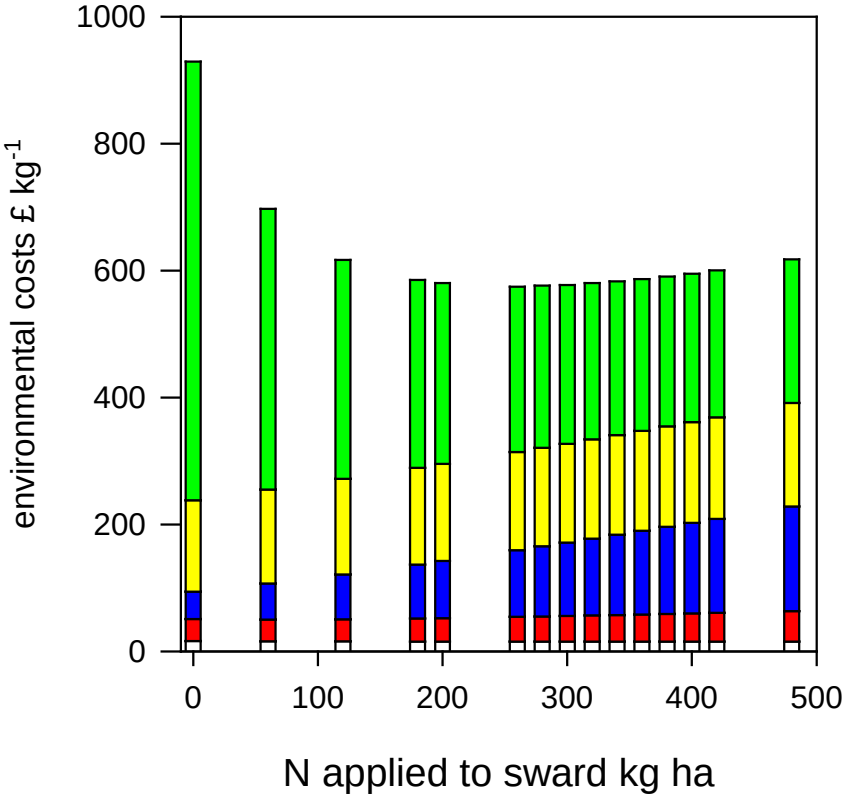
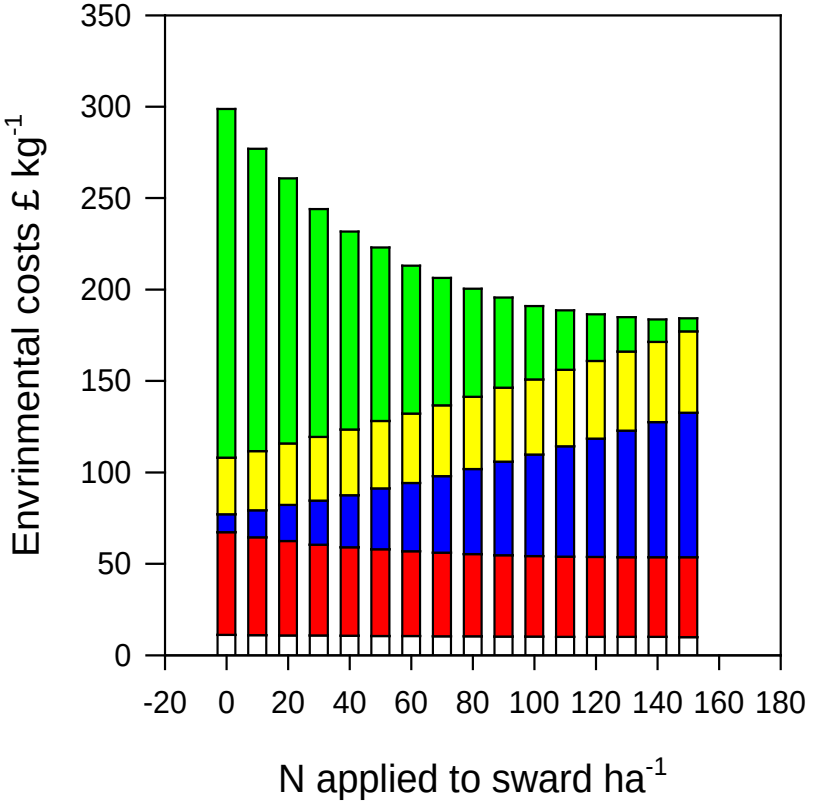
Breakdown of environmental costs and burdens for livestock systems

ROTHAMSTED RESEARCH

Grazed18 month beef



3 month finishing grazed lambs



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Extensification vs Intensification

Land Sharing vs Land Sparing

- Extensification reduces inputs, emissions and yields
- Needs more land
- Intensification increases yield, inputs and emissions?
- Needs less land

Some ‘Win-Win’s

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Broadbalk: mean yields of wheat grain, cultivars and major changes

1st wheat, FYM+N3

Fungicides

Modern cultivars

1st wheat, Best NPK

Cont. wheat, N3PK

Herbicides

Liming

Fallowing

Cont. wheat, FYM

Continuous wheat, unmanured

Grain, t/ha at 85 % dry matter

10 9 8 7 6 5 4 3 2 1 0

1840 1860 1880 1900 1920 1940 1960 1980 2000 2020

Red Rostock Red Club Sq. Master Red Standard Sq. Master Cappelle D. Flanders Brimstone Apollo Hereward Crusoe

Introduction of modern dwarf cultivars

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Total Factor Productivity

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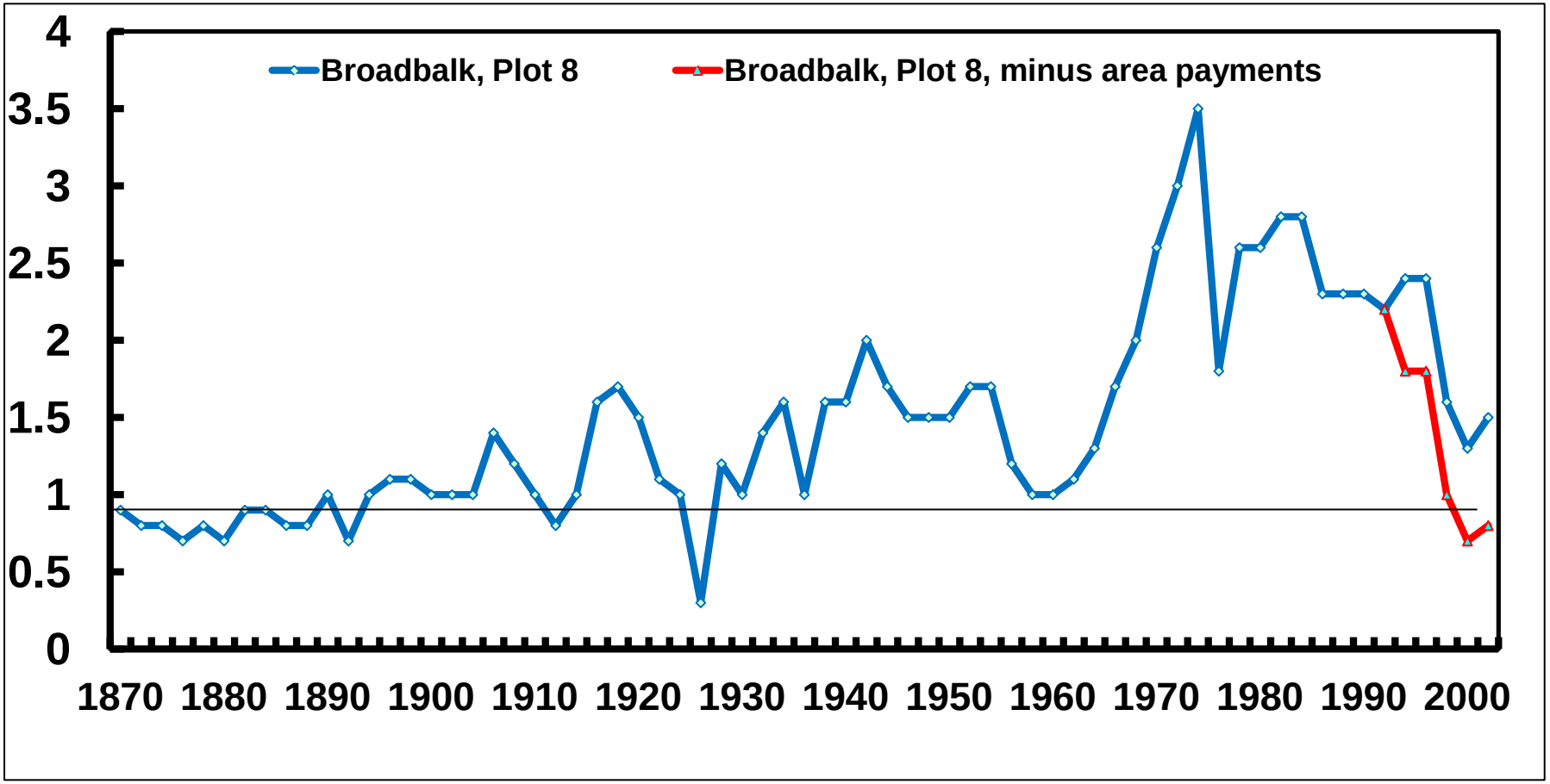
Broadbalk Continuous Wheat experiment

TFP (Profitable if > 1)



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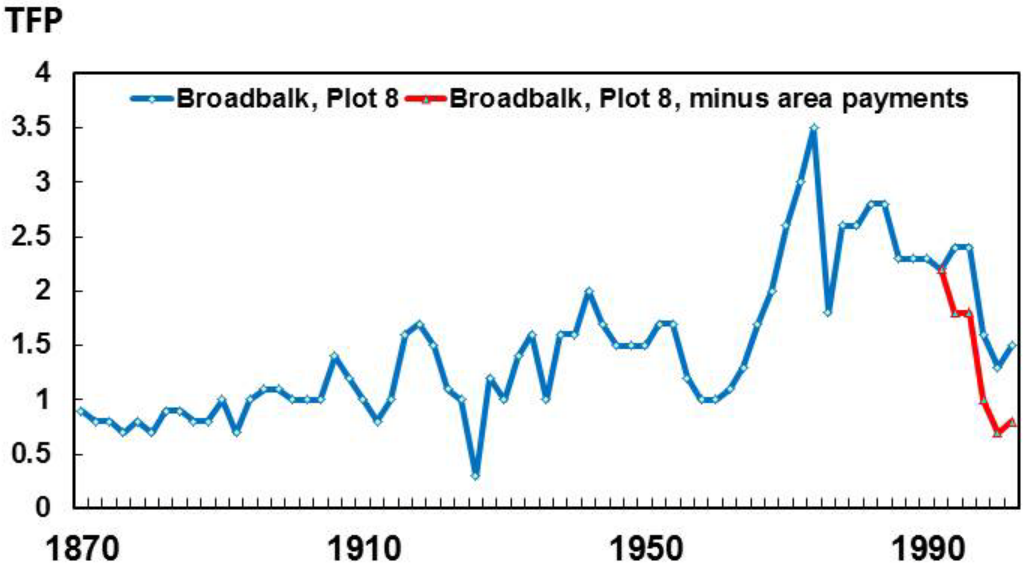
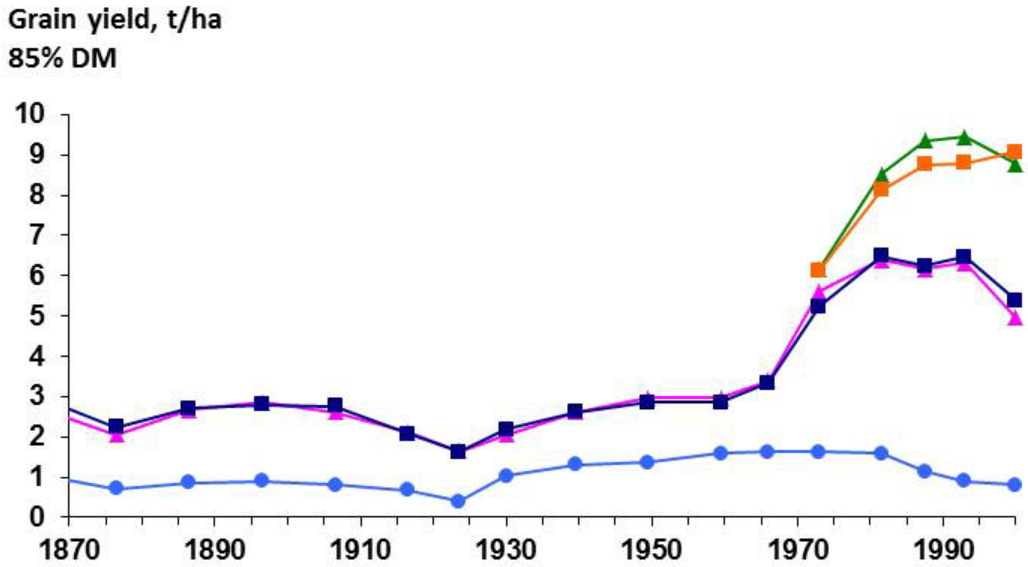
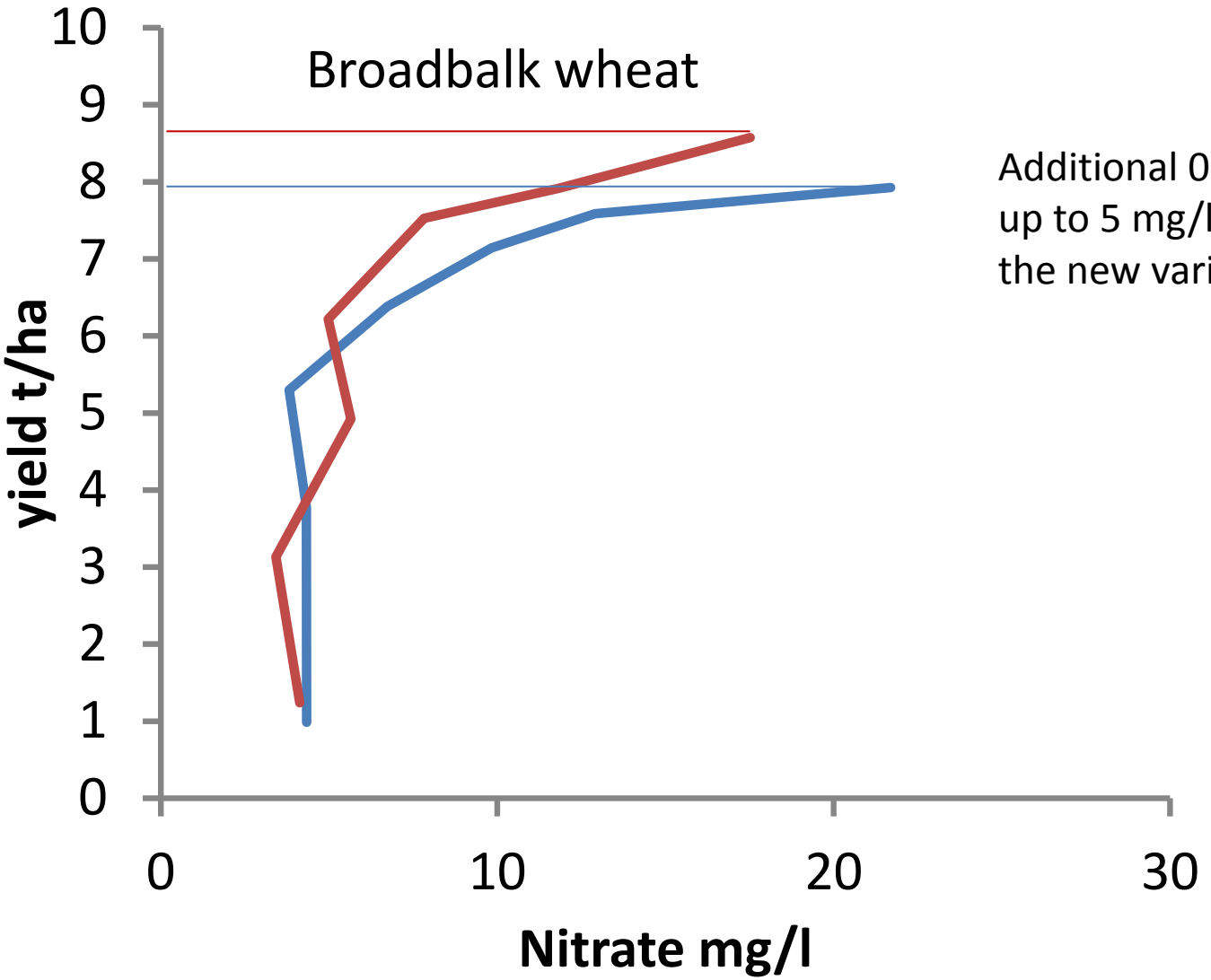
Broadbalk yields and TFP, 1870 - 2000



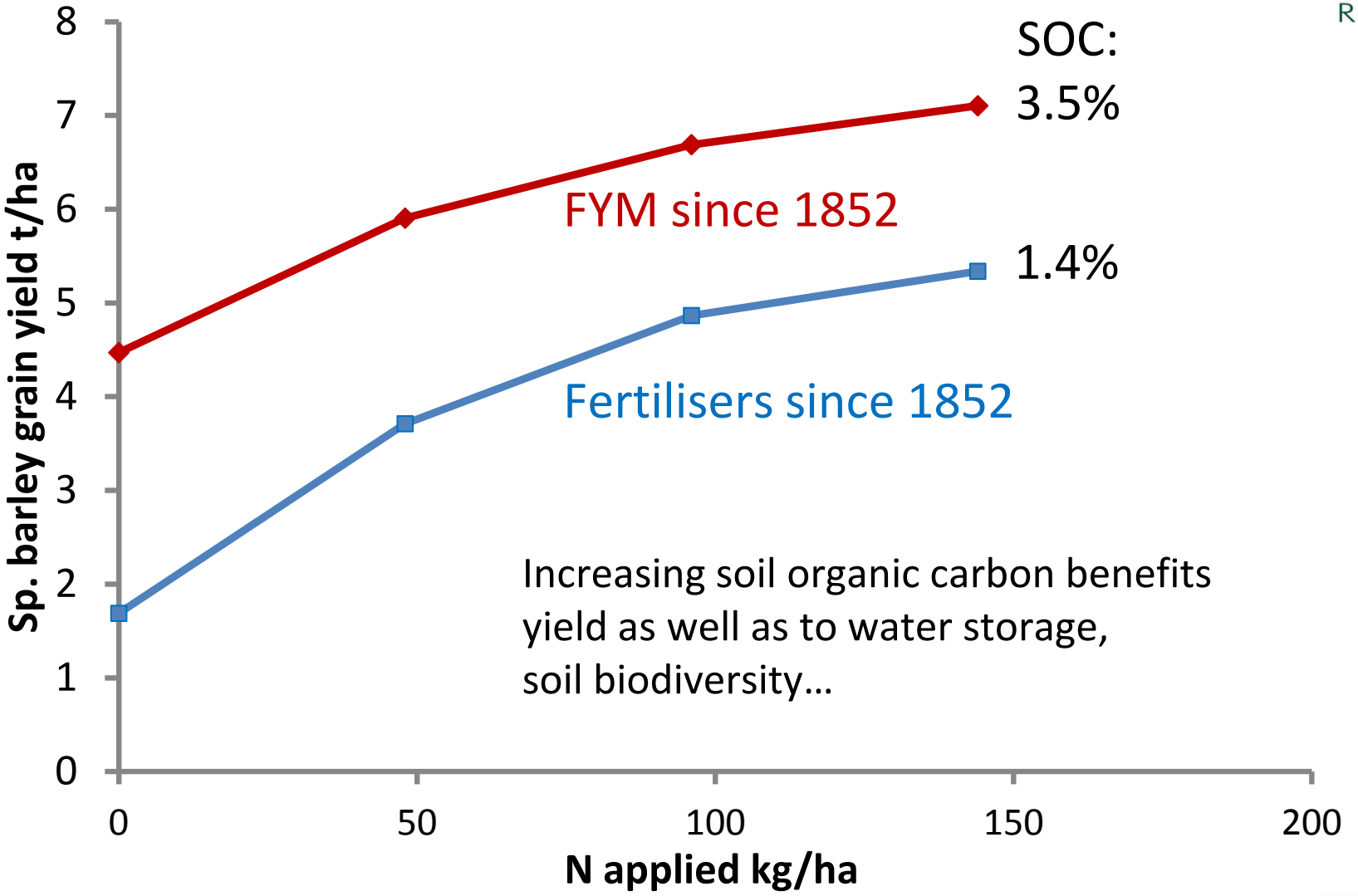


Win-Win: Breeding for yield brings environmental benefits?

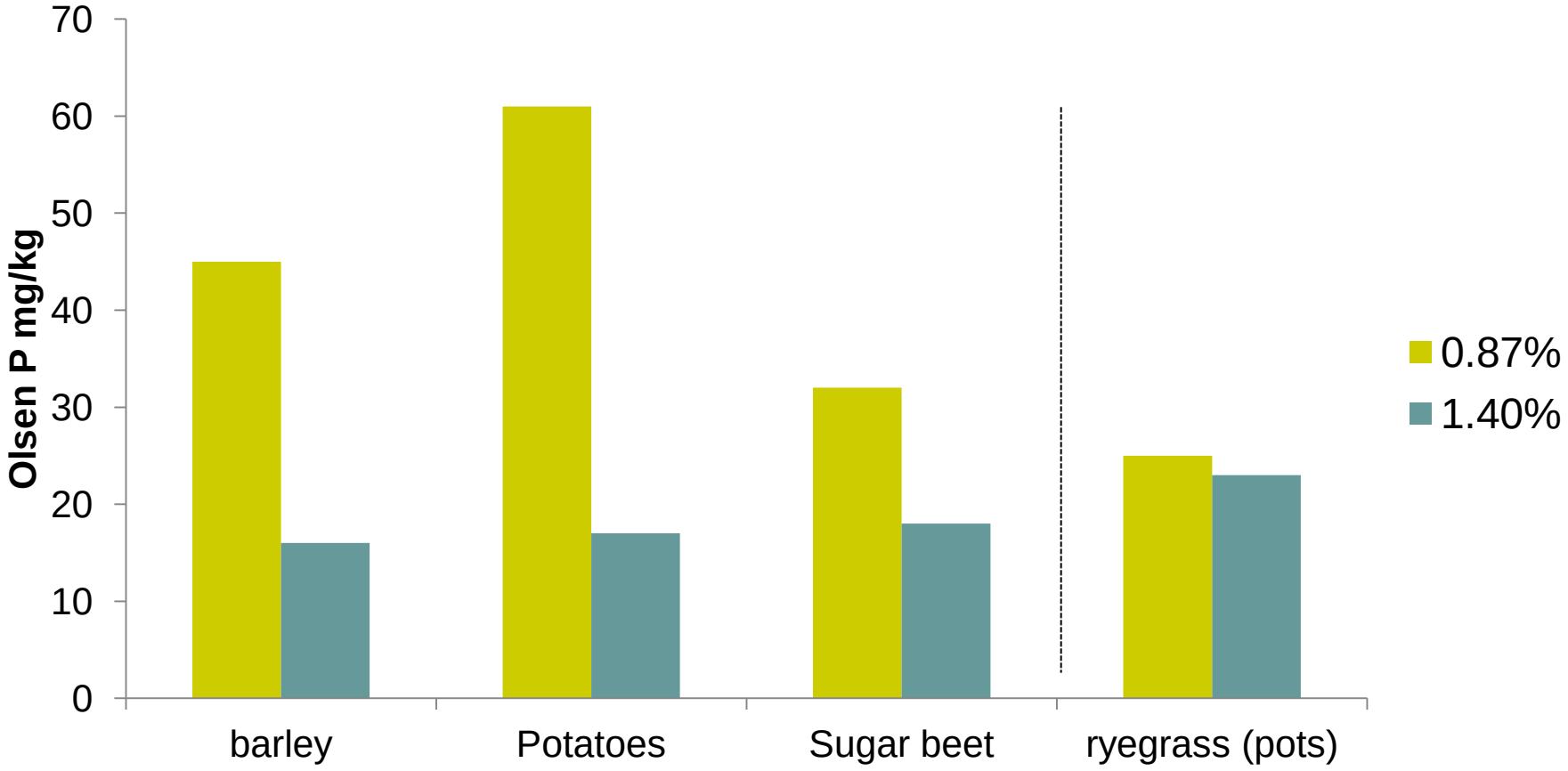


Additional 0.8 t/ha yield and up to 5 mg/l less nitrate from the new variety

Win-Win-Win…:
Benefits of soil organic matter/carbon

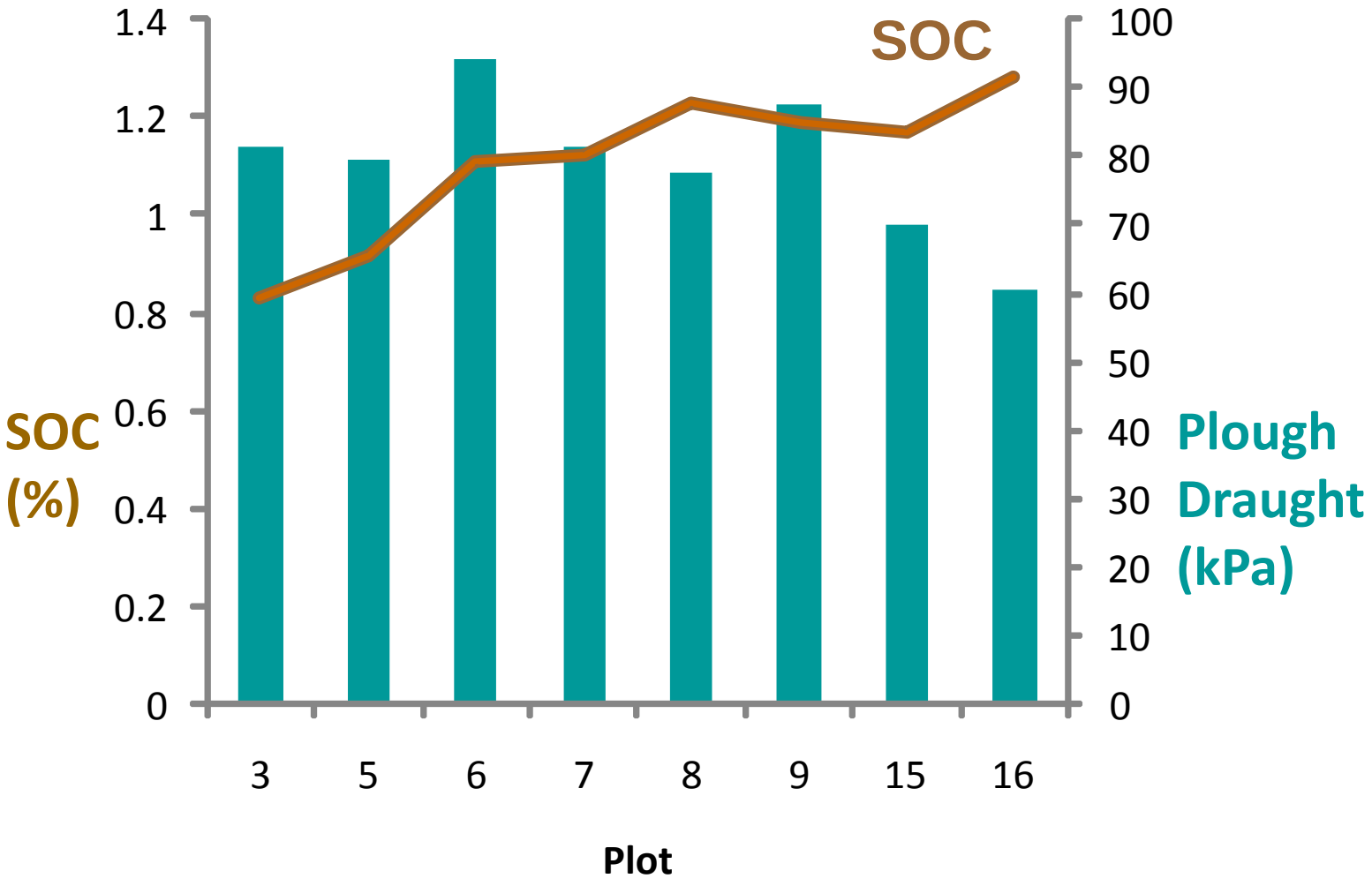


Moving the threshold: Olsen P required for 95% yield at two SOC levels



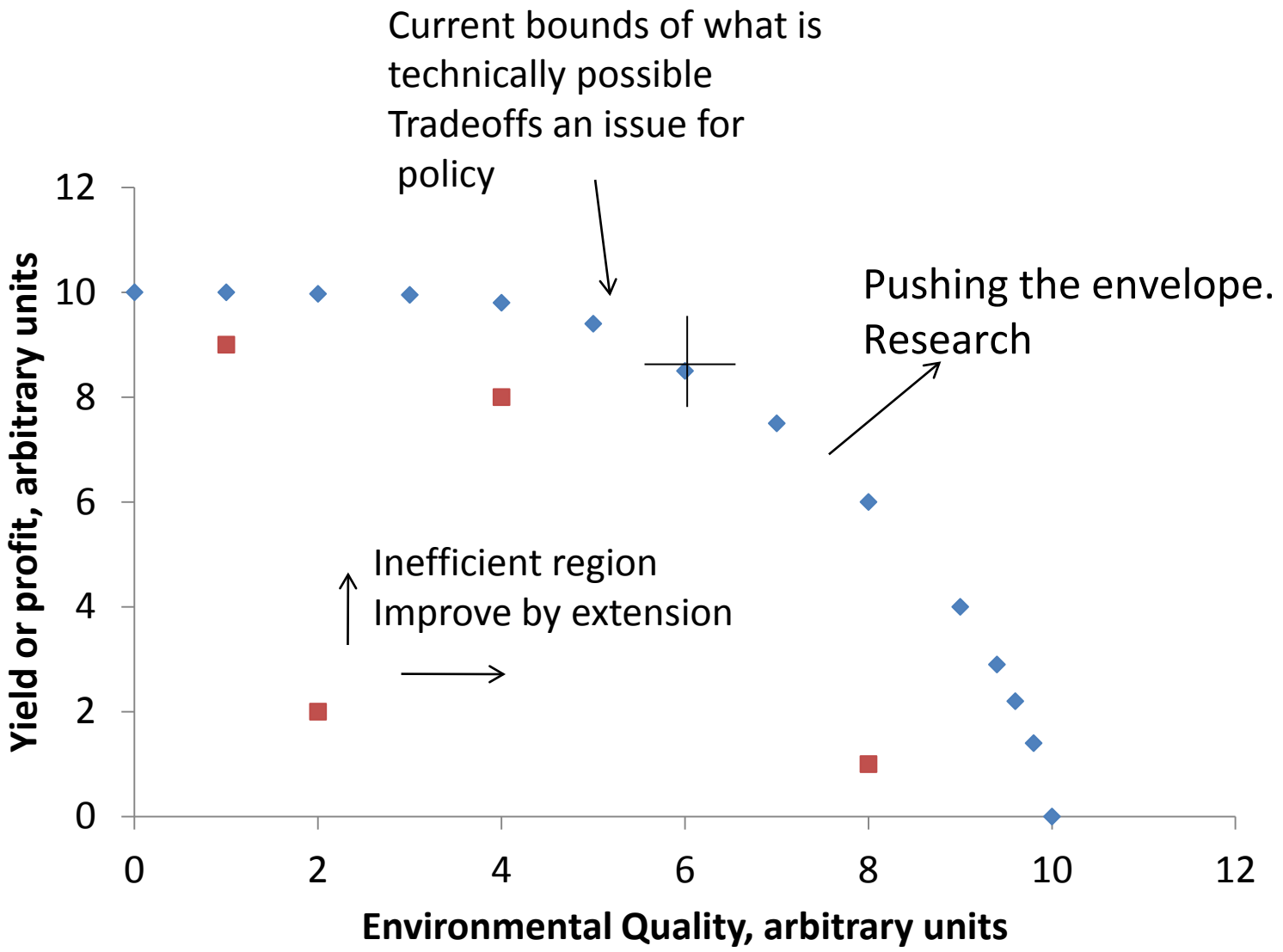
Johnston *et al*., 2009, *Advances in Agronomy* **101**, 1-57.

Draught force and SOC in the Broadbalk winter wheat experiment



Watts *et al*., 2006, *Soil Use & Management* **22**,*334-341.*

Possibility Frontier



Key factors in sustainability

- Resilience, particularly economic (prices, yields)
- Ecosystem Services – will farmers be paid for more than yield?
- Stability, i.e. minimal variation (effective control of pests and diseases; mitigating climate change)

Acknowledgements

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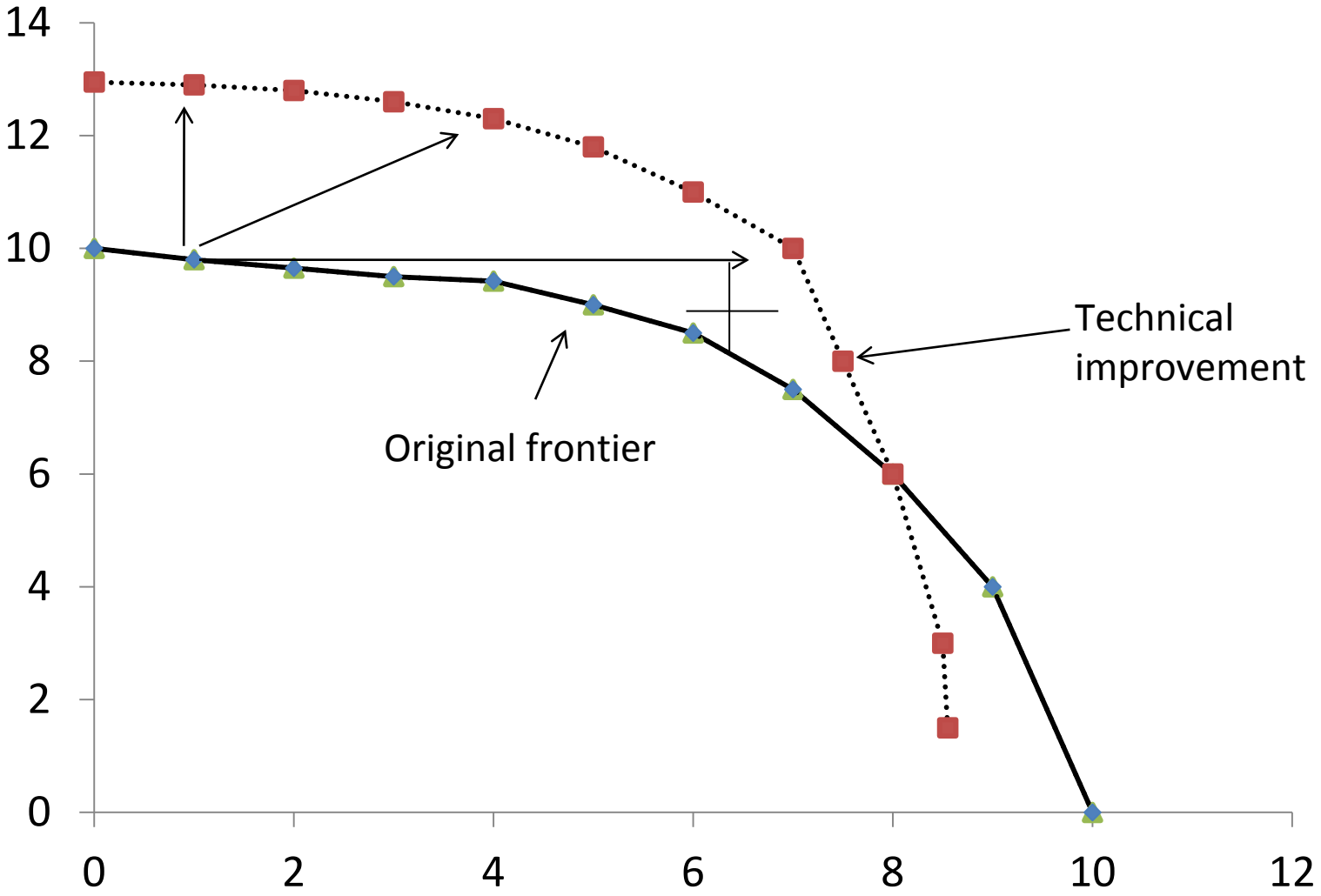
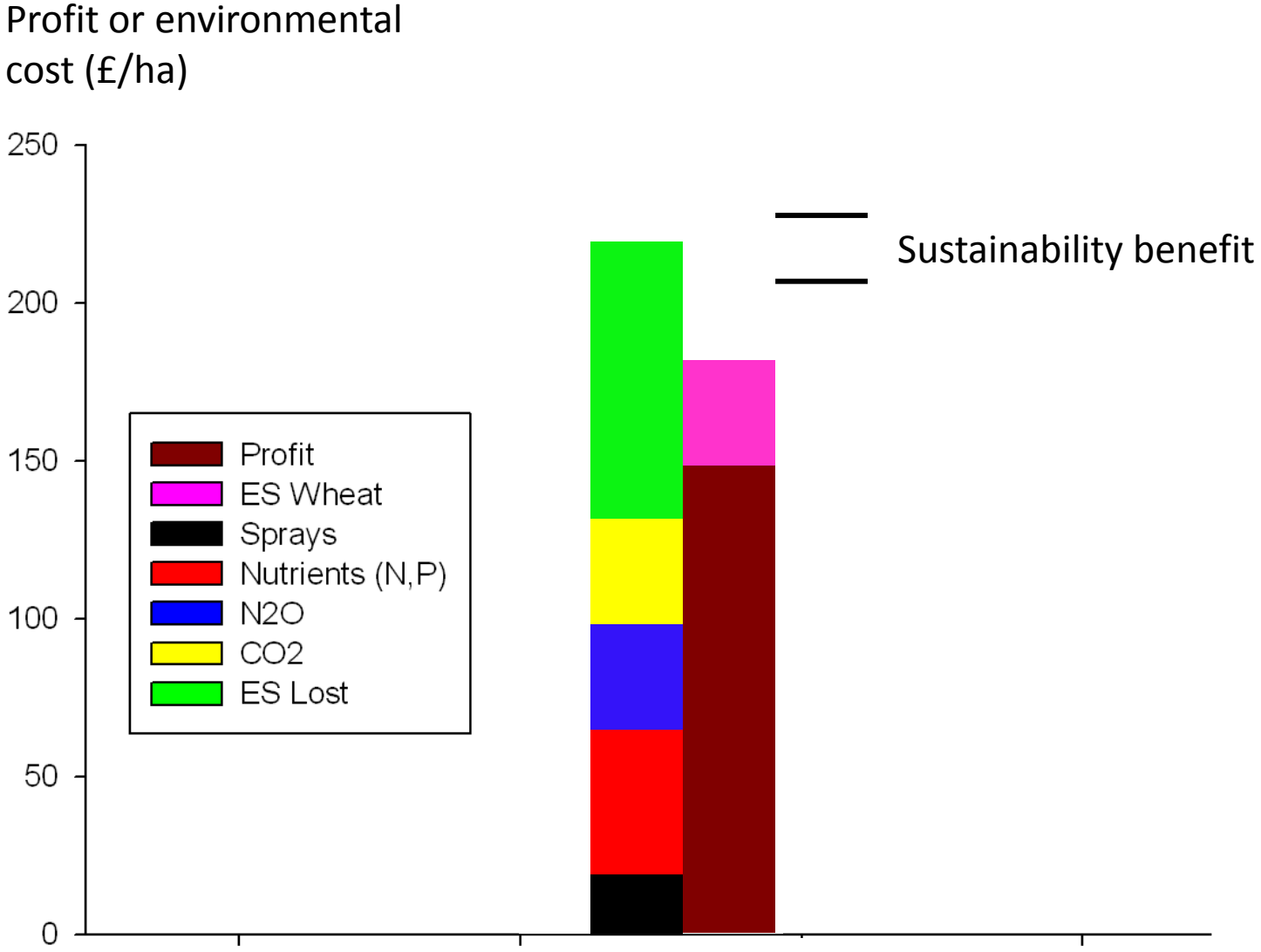
…and some by the UK Department for Environment, Food and Rural Affairs.

Research can move the possibility frontier



Moving towards sustainability



Pigs and broiler production