Modelling the effects of a large scale conversion to organic farming in England and Wales

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Research Question: how would a large scale conversion to organic agriculture in England and Wales meet the demands for a lower environmental impact yet more productive agriculture?

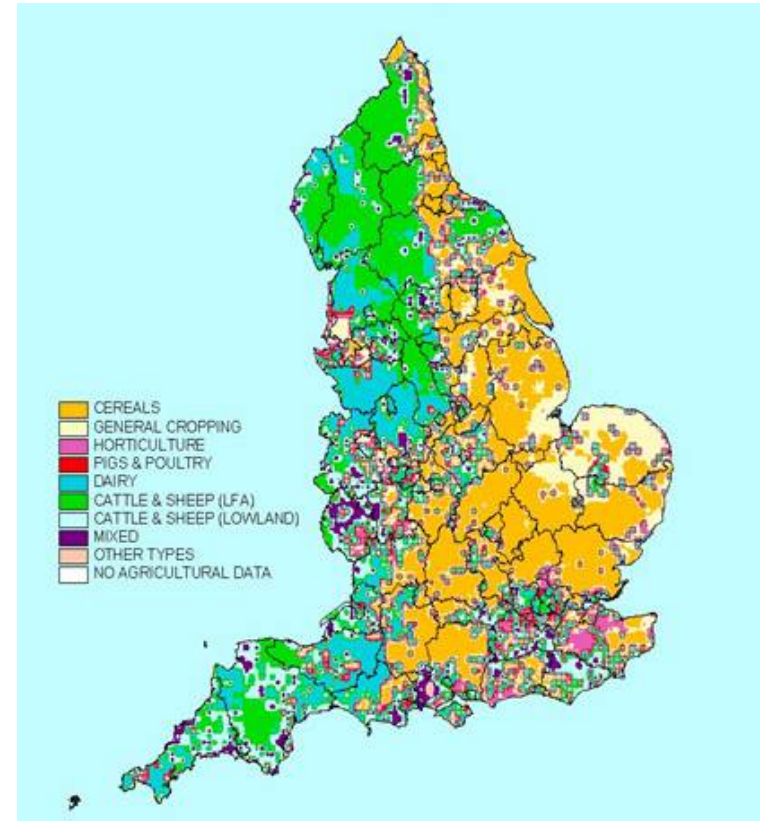**Working hypotheses:**

Hypothesis 1:
A 100% conversion of agriculture in England and Wales to organic practices will not significantly reduce the levels of production for major arable and horticultural crops and livestock products.

Hypothesis 2:
A 100% conversion of agriculture in England and Wales to organic practices will not result in a net increase in greenhouse gas emissions.

Modelling approach selected:

- Assume that current structure of the industry (by Robust Farm Type) represents an optimum, given that each farm is facing multiple constraints.

- The **_dominant enterprise_** will remain in place e.g. a dairy farm will remain a dairy farm. Considerable changes will still be observed within each farm type

- A Linear Programming model will be tasked with maximising energy production, subject to constraints

CEREALS
GENERAL CROPPING
HORTICULTURE
PIGS & POULTRY
DAIRY
CATTLE & SHEEP (LFA)
CATTLE & SHEEP (LOWLAND)
MIXED
OTHER TYPES
NO AGRICULTURAL DATA

Source: Defra

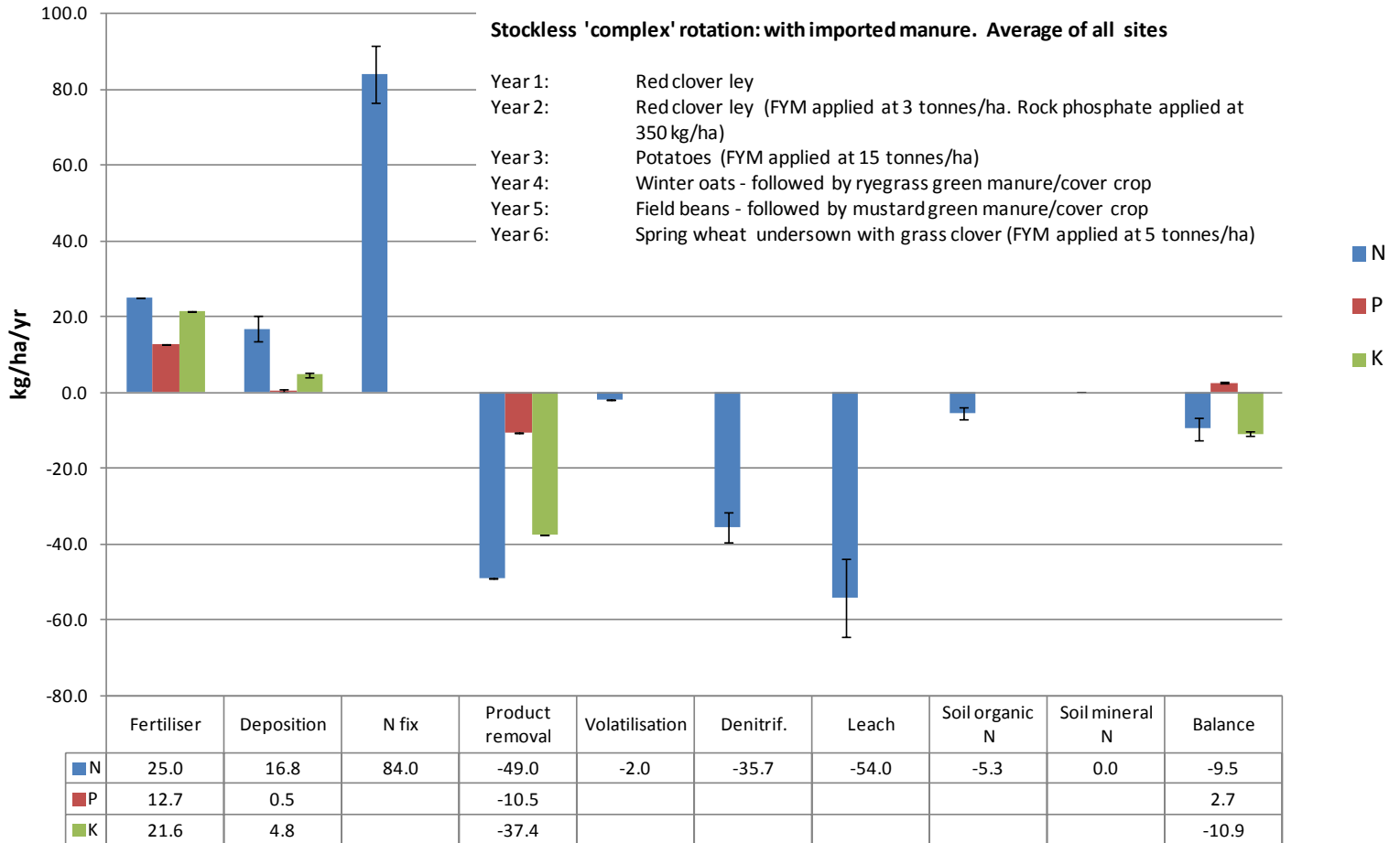# Key constraint: N availability by rainfall and soil

- Nitrogen availability within a range of soil and rainfall combinations was set as a limiting factor

Rainfall	East Midlands: Land area by soil type ('000 ha)			
	Organic	Heavy	Medium	Light
540-635 mm	50	2700	1800	1000
636-723 mm	0	1080	900	0
724+ mm	0	1800	900	0

- The N balance for each soil/rainfall combination were calculated using NDICEA

- Nutrient balances from NDICEA will weight yields of crops in typical rotations on farm types

Key constraint: N availability by rainfall and soil

- Nitrogen availability has been determined using typical organic rotations and stocking rates:
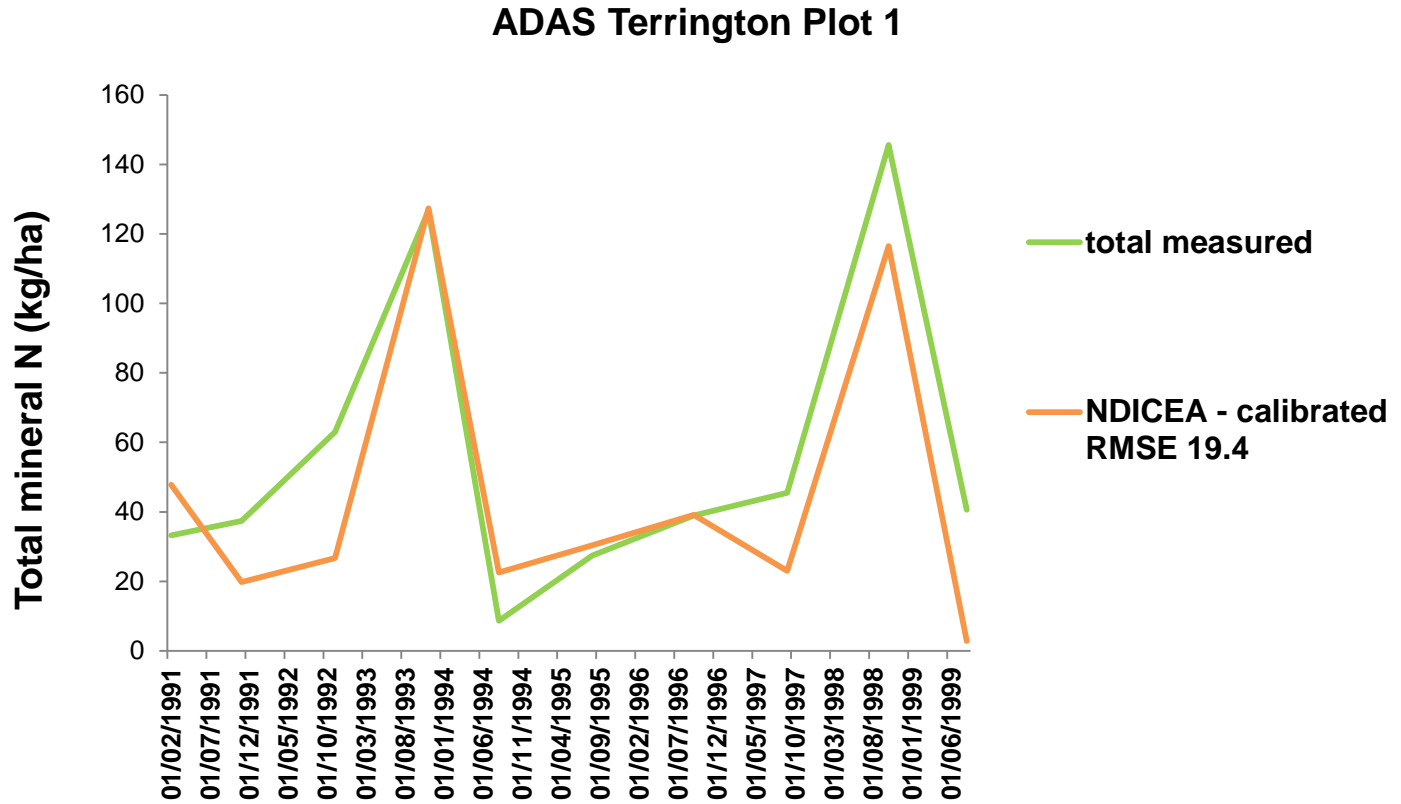

Stockless 'complex' rotation: with imported manure. Average of all sites

Year 1:	Red clover ley
Year 2:	Red clover ley (FYM applied at 3 tonnes/ha. Rock phosphate applied at 350 kg/ha)
Year 3:	Potatoes (FYM applied at 15 tonnes/ha)
Year 4:	Winter oats - followed by ryegrass green manure/cover crop
Year 5:	Field beans - followed by mustard green manure/cover crop
Year 6:	Spring wheat undersown with grass clover (FYM applied at 5 tonnes/ha)

	Fertiliser	Deposition	N fix	Product removal	Volatilisation	Denitrif.	Leach	Soil organic N	Soil mineral N	Balance
N	25.0	16.8	84.0	-49.0	-2.0	-35.7	-54.0	-5.3	0.0	-9.5
P	12.7	0.5		-10.5						2.7
K	21.6	4.8		-37.4						-10.9

Source: Defra project OF03100: Assessing the Sustainability of Organic Crop Yields and Rotations

Challenges in the modelling process: N fixation and N availability: highly variable!
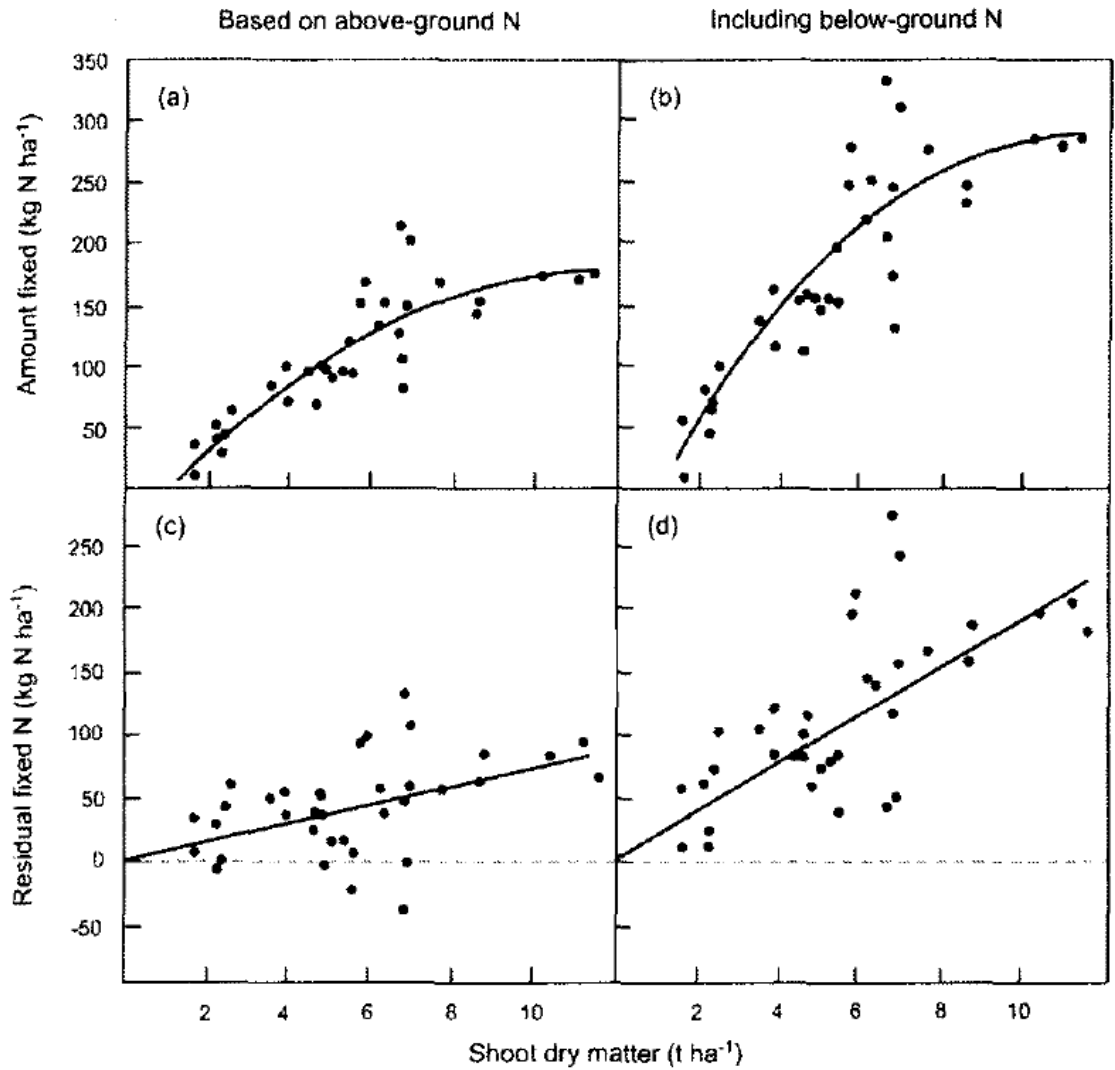
Source: Peoples et al. (2009) The contributions of nitrogen-fixing crop legumes to the productivity of agricultural systems

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Estimates of N availability produced by NDICEA close to recorded data:

ADAS Terrington Plot 1

total measured

NDICEA - calibrated RMSE 19.4

Comparison of modelled amounts of soil N produced by NDICEA to field measurements (RMSE = Root Mean Square Error)

Source: Defra project OF03100 Assessing the Sustainability of Organic Rotations and Crop Yields

Finding activity data on organic crop yields

- Have been able to obtain averages, although ranges are provided, cannot distinguish between position in rotation

- Planning to consult experts for estimates following a Delphi approach

- Also missing data on oilseed rape, sugar beet and other 'non-organic' crops
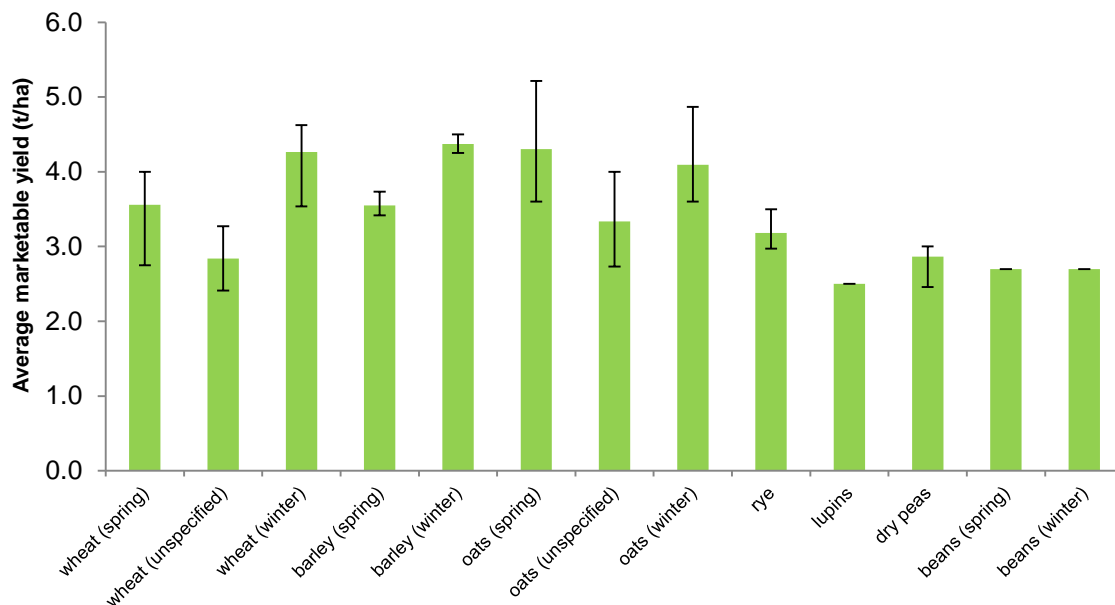
Source: Data collected from dePonti et al. (2012), Seufert et al. (2012) and expert survey
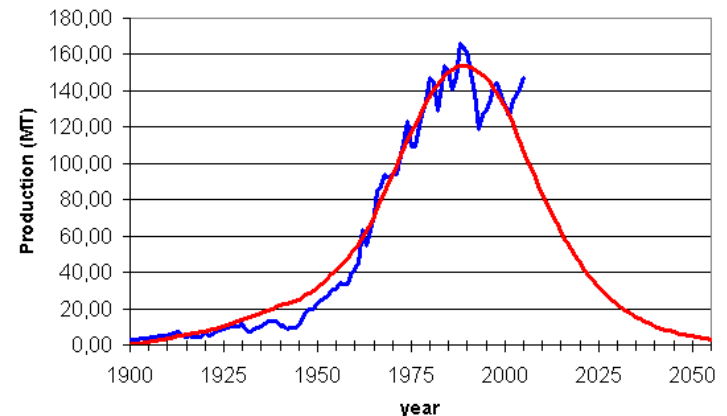
Challenges in the modelling process

- Farm type specification for cereal farms: very few organic specialist cereal producers – tend to fall under the 'general cropping' farm type i.e. a mix of crops including potatoes and other veg.

Source: David Wilson, Duchy Home Farm (2014)

- Have decided to amalgamate area of specialist cereal and general cropping for the time being

- Imported compost and feed: limits to availability? Would sewage sludge be available in a 100% organic scenario?

World rock phosphate production

Source: Cordell et al. (2009)

- Inter-farm transfers of manure: to what extent would this be feasible?

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Challenges in the modelling process

- Linear programming (LP) approach used within this study

	Products		
	A	**B**	**Available**
Assembly (hours)	2	4	100
Finishing (hours)	3	2	90
CM/unit	$25	$40	

- A LP will maximise (or minimise) an objective function subject to constraints

- Jumpy behaviour in linear modelling- from one extreme to another

- Repeated runs and model adjustments can overcome this

Source: http://linkwall.blogspot.co.uk/
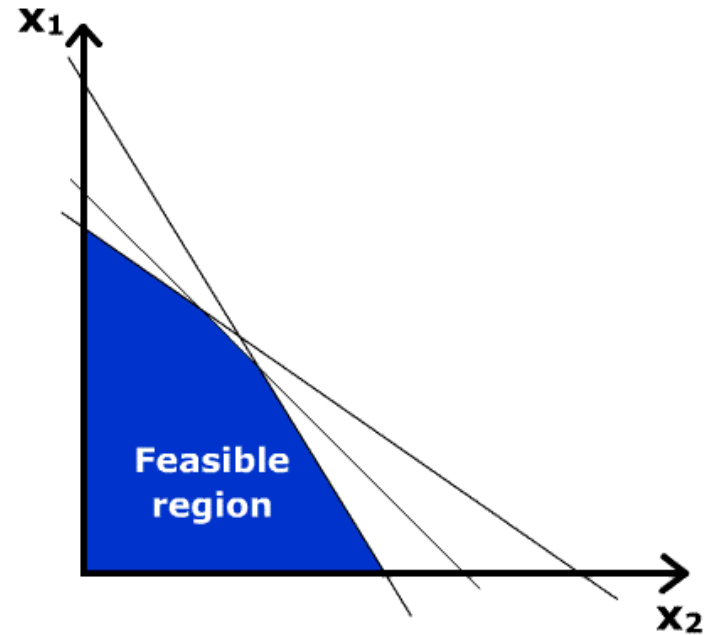
Other challenges:

- Scaling up a small sector – difficult to predict what a 100% organic England and Wales would look like

- Funding for the remaining activity: organic farming not a priority for research funding

- Delays in obtaining data from official providers

- Lack of researchers working on similar topics within the UK

In Summary:

The main challenges to date mainly related to data availability in the following areas:

- N fixation by legumes
- Crop yields by position in rotation
- Crop yields for 'non-organic' crops such as sugarbeet
- Organic farm typology for specialist cereals and stockless farms
- Scaling up a small sector to 100% of farmed area

Other challenges relate to perception of the organic sector, this is changing rapidly but remains an issue

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