Integrated approaches to farming systems research – pleasure or pain?

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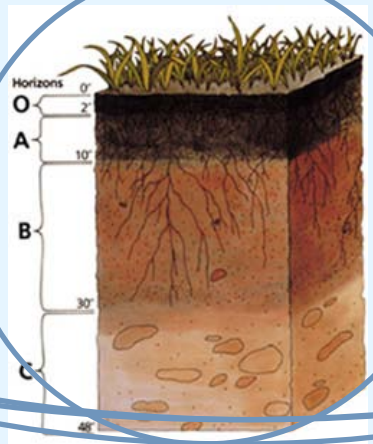
SAC Research

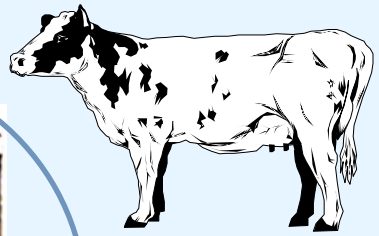
27 October 2010, SLU, Uppsala

What do we mean by integrated approaches?

- Multidisciplinary or Interdisciplinary or Transdisciplinary?
- Integrated across scales?
- Integration between experimentation and modelling?
- Integration with stakeholders?

View of the world





The seminar plan

- Examples - 4 projects where we have used various integrated approaches
- Analyse what is integrated about them – successes and failures
- Barriers to integration
- Was it pleasure or pain?

Examples

- WP1.7 Scottish Cropping Systems
- Pig production systems
  - ECOPIG
  - GreenPig
- MACC

Developing sustainable multi-functional cropping systems in Scotland: integrating disciplinary approaches and scales

Christine Watson, Bruce Ball, Steve Hoad, Neil McRoberts, Kairsty Topp (SAC)

Paul Hallett, Cathy Hawes, Pete Lannetta, Geoff Squire (SCRI)

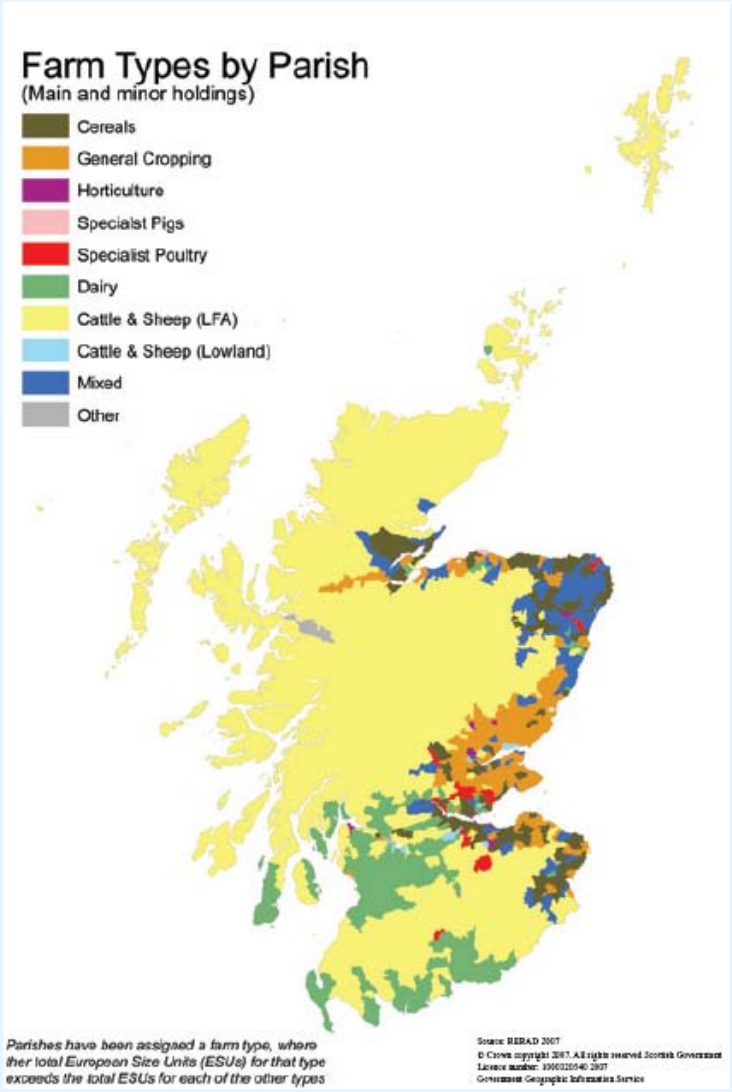
Required Output 1: Understand and define quantitatively the social, economic and environmental components that confer resilience on arable land use systems.

Required Output 2: Understanding of how crop management practices may be developed and used to optimise the management of these components, particularly those reducing or reversing adverse environmental impacts whilst maintaining economic sustainability.

Scottish Agriculture – production is no longer enough

- “encourage farming practices which contribute to the economic, social and environmental sustainability of rural areas”
  Forward Strategy for Scottish Agriculture, 2001

2009	ha
Wheat	113,797
Barley	319,934
Oats	21,720
OSR	33,623
Potatoes	29,836
Other crops	17,815
Horticultural crops	14,180


Farm Types by Parish
(Main and minor holdings)
Cereals
General Cropping
Horticulture
Specialist Pigs
Specialist Poultry
Dairy
Cattle & Sheep (LFA)
Cattle & Sheep (Lowland)
Mixed
Other
Parishes have been assigned a farm type, where ther total European Size Units (ESUs) for that type exceeds the total ESUs for each of the other types
Source: RERAD 2007
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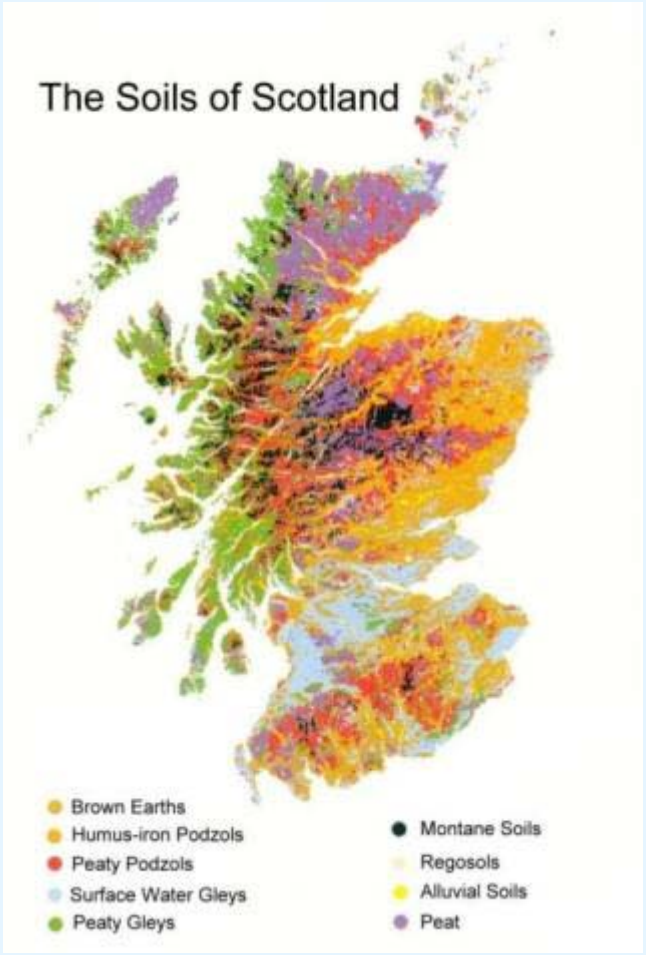
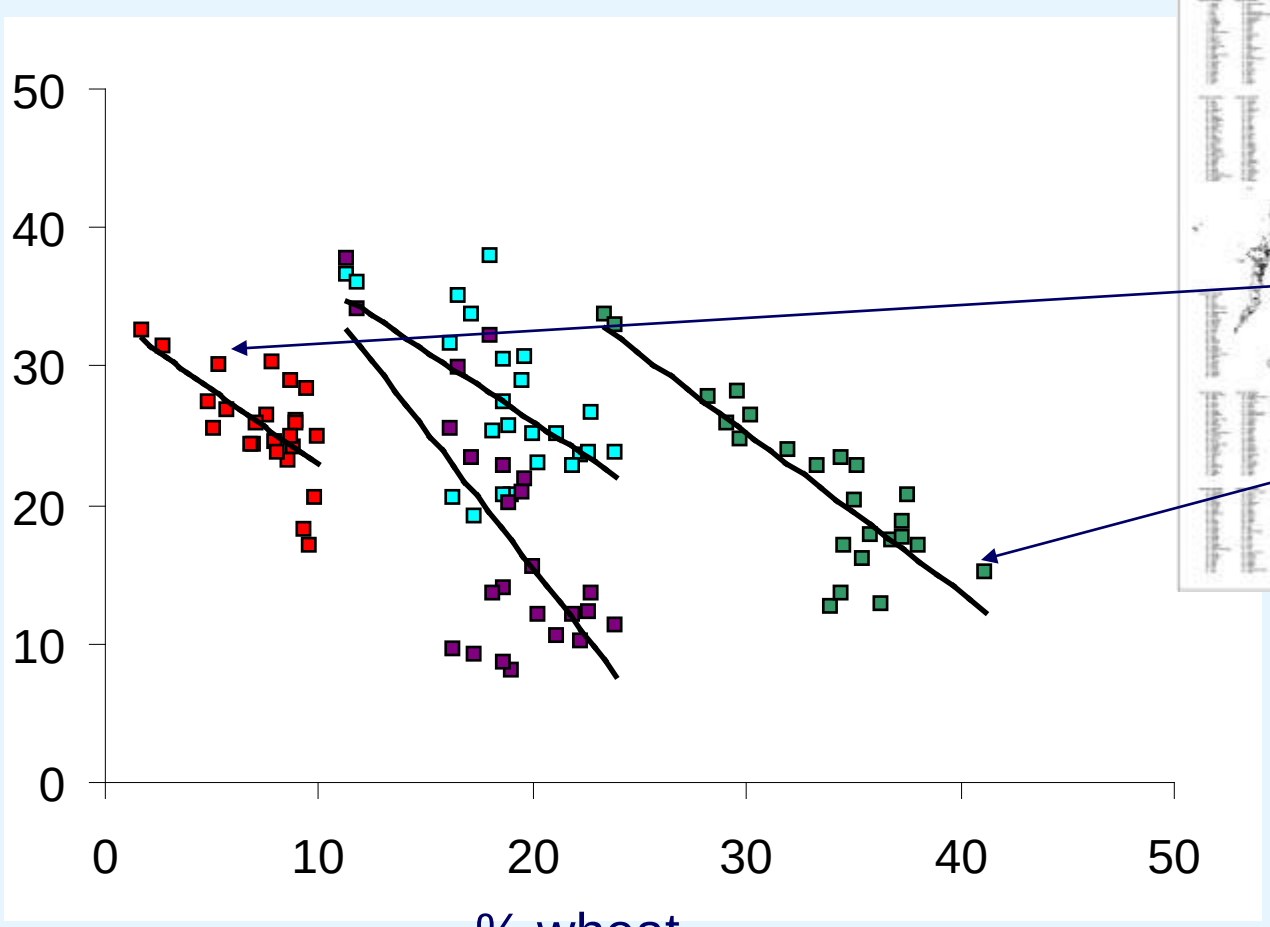
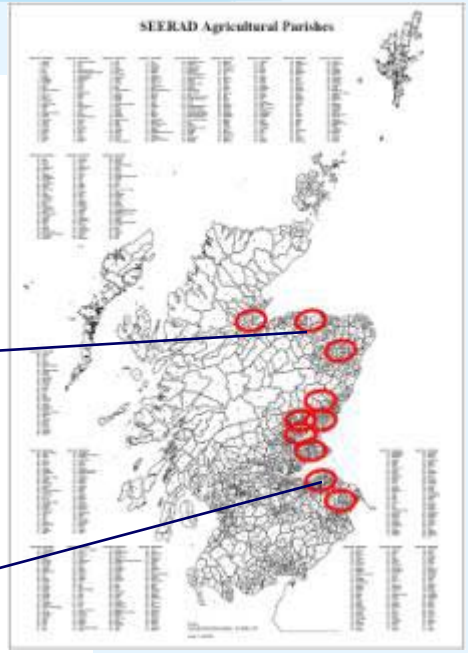
Government Geographic Information Service


The Soils of Scotland
Brown Earths
Humus-iron Podzols
Peaty Podzols
Surface Water Gleys
Peaty Gleys
Montane Soils
Regosols
Alluvial Soils
Peat

Historical change over 25 years



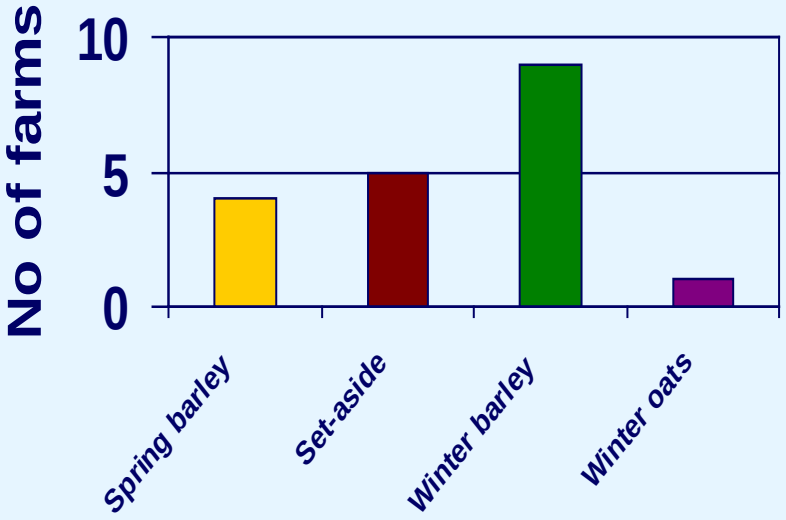


a baseline for indicators

- state indicators (basic data set)
  - soil biophysical, microbial
  - crop, weed, seedbank and food web
  - energy, carbon, nutrients – pools and fluxes
  - emissions to air and water
  - Management including agronomic inputs, outputs, costs

Farming systems variability

2007 Survey of 58 arable farms in Eastern Scotland – data from 19 farms growing Winter Oil Seed Rape.

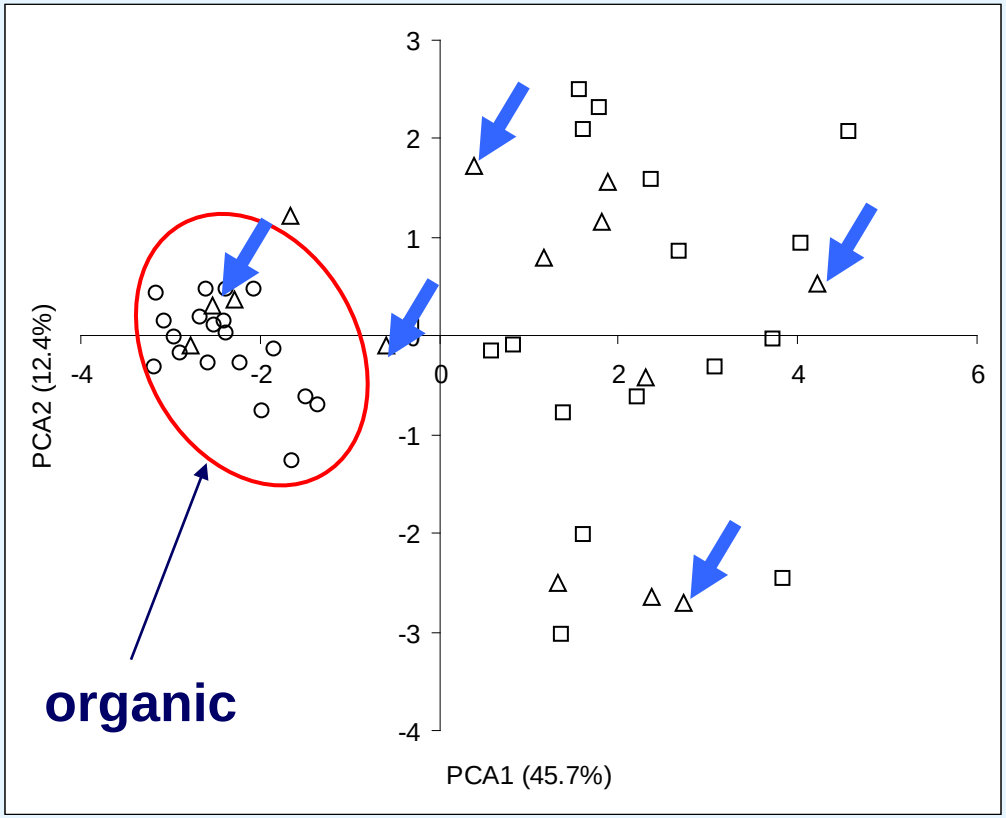


Management

- 10 different varieties
- 11 seed rates (2.3-6 kg/ha/yr)
- 12 herbicide treatment combinations
- 9 cultivation treatment combinations

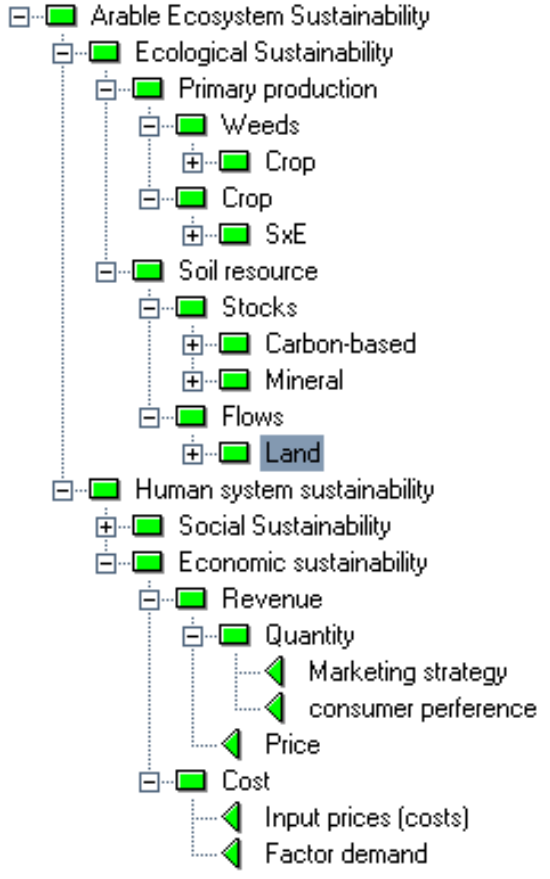
What drives the indicators: vegetation

- each symbol is one field
- multivariate assessment based on agronomic and field variables
- organic (circle) separate from conventional (square)
- integrated (triangle) varies over a wide range (examples shown by blue arrows)
- main factors are: fertiliser, pesticide, field margins



Hawes et al. 2010 Ag Eco Env

DEXI ANALYSIS – What do we collectively already know?

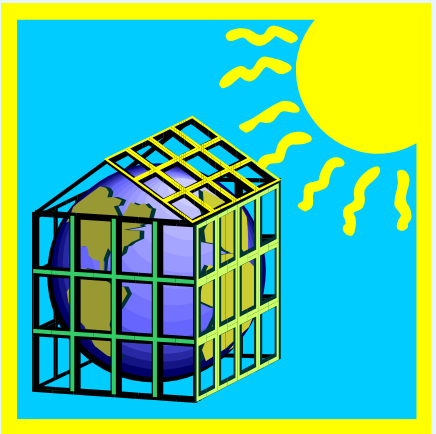


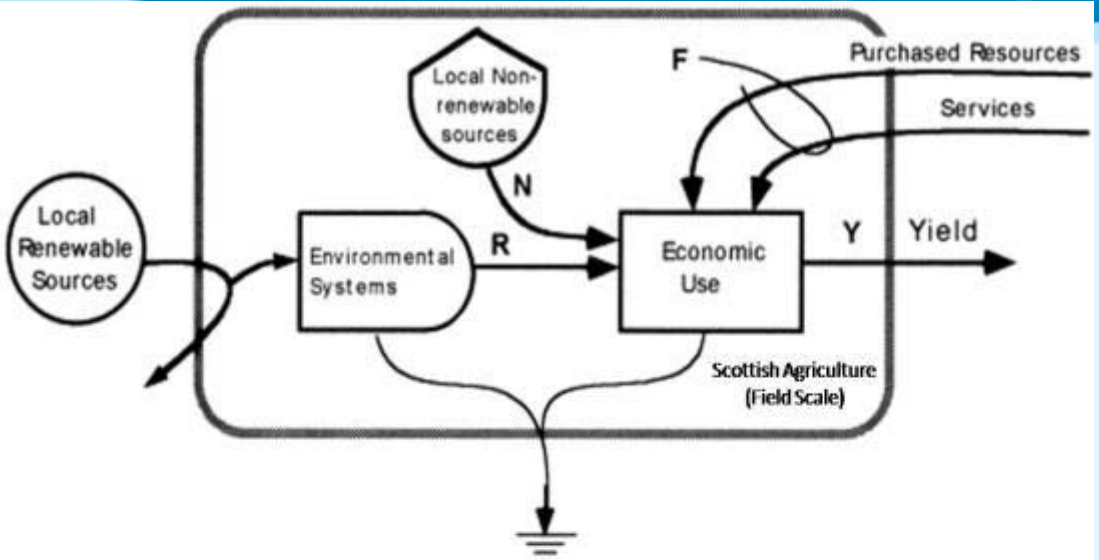
Advantages of multi-attribute approach

1. Relatively quick to build
2. Can mix informal knowledge and data
3. Level of detail can vary
4. Sub-models can be constructed independently
5. Overall properties emerge from linking sub-models
6. Model utilises linguistic rather than mathematical representation: more accessible to non-scientists
7. Generic model syntax (XML) allows simple dissemination of model

Emergy

- A holistic alternative for environmentally conscious decision making
- Connects economics and ecological aspects
- Assesses renewable, non-renewable and purchased resources
- Based on a common currency





Yield (Y) = R+N+F

Φ_R= Fraction Renewable = R/(R+N+F)

Emergy Yield Ratio = EYR = Y/F

Environmental Loading Ratio = ELR = (F+N)/R

Emergy Sustainability Index = ESI = EYR/ELR

Resource Type	Includes
Renewable	Solar Radiation, Rainfall, Earth Cycle
Non-Renewable	Net loss from the topsoil
Purchased	Fuel, Labour, Fertilisers, Pesticides, Mechanical equipment
Exports	The crop grown

Emergy- Preliminary Results

Emergy Indices	Spring Barley	Winter Oilseed
Fraction Renewable	1.97E-07	1.97E-07
EYR	1.03E+07	5.79E+06
ELR	5.08E+06	5.08E+06
SI	2.02	1.14

- Spring barley has a higher SI = Utilises renewable resources readily
- Spring barley is exploiting resources more efficiently
- Winter oilseed is more reliant on non-renewable resources

- **What we plan to do next:**
  - Compare farm systems
  - Compare crop types
  - Analysis on a per tonne of product basis

How well did this work?

The good bits

- A great multi-disciplinary dataset
- Many new collaborations
- Possibility for spatial and temporal modelling
- 5 years on we have a team who are starting to pull together!
- Starting to tackle scaling issues

Challenges

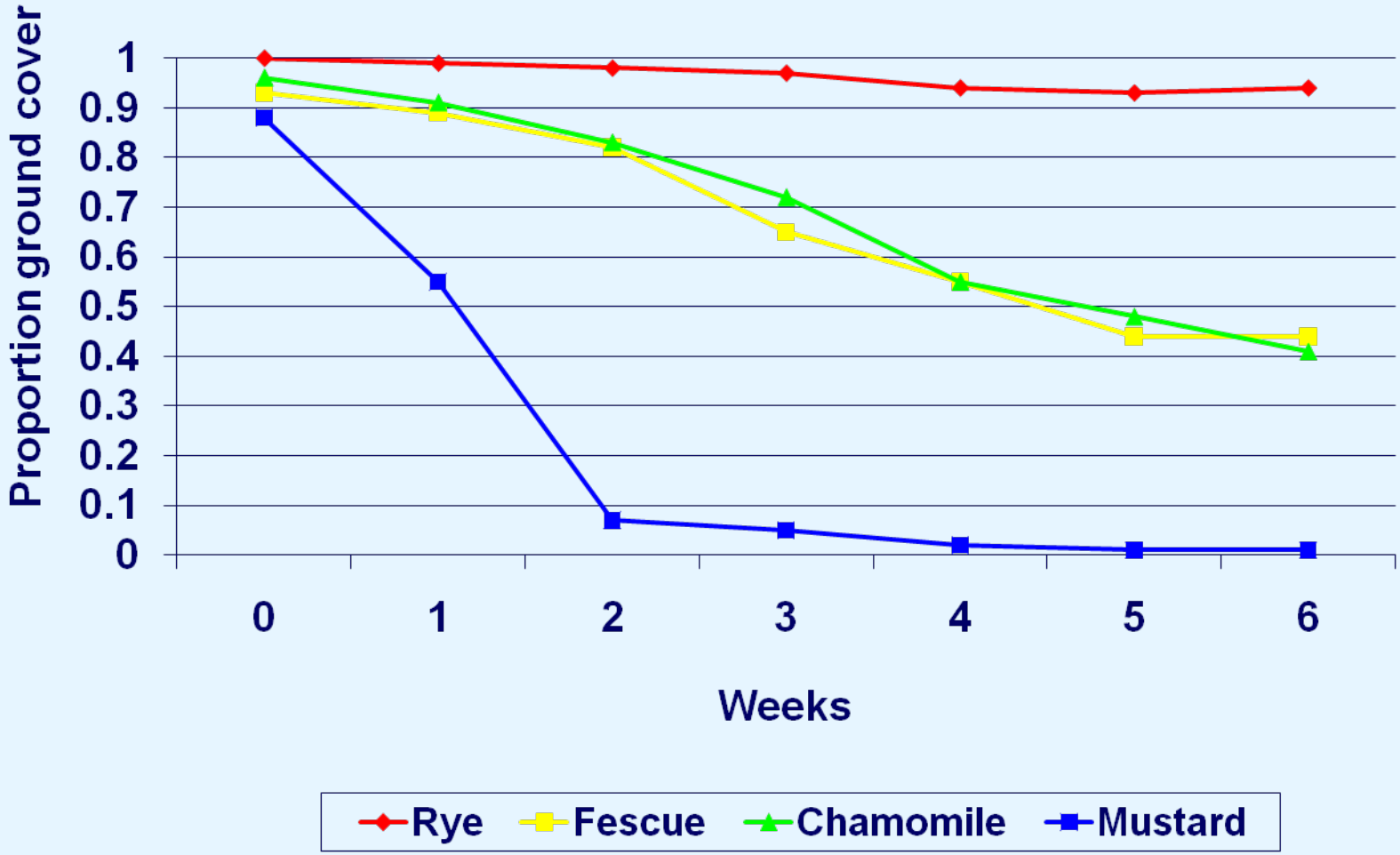
- Objectives too broad
- An “arranged marriage” with personality/cultural problems (institutional and individual)
- Lots of time wasted on unimportant issues
- Minimal stakeholder involvement (could have been good if managed better)
- Mostly multi-disciplinary

ECOPIG – are outdoor pigs compatible with a clean environment?

ECOPIG project

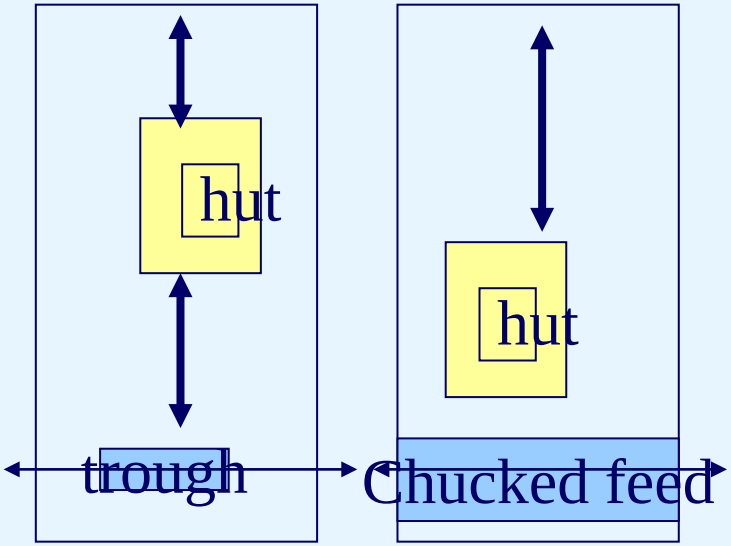
- In environmental terms loss of vegetation is the biggest problem associated with outdoor pig production

ECOPIG - Persistence of vegetation with time under different ground covers

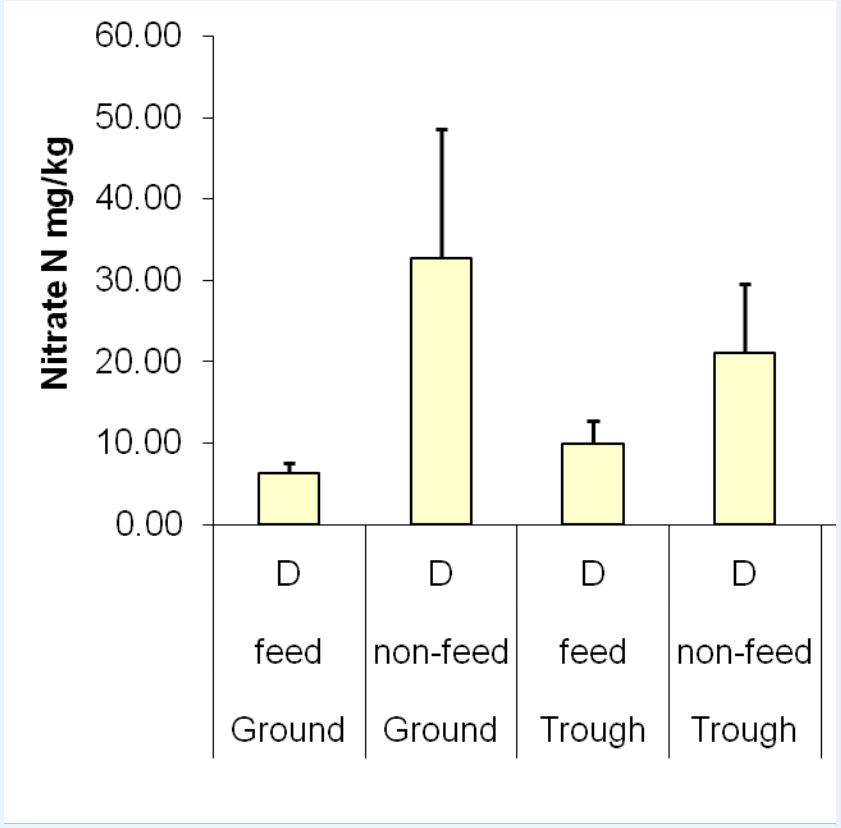


Reducing feed wastage

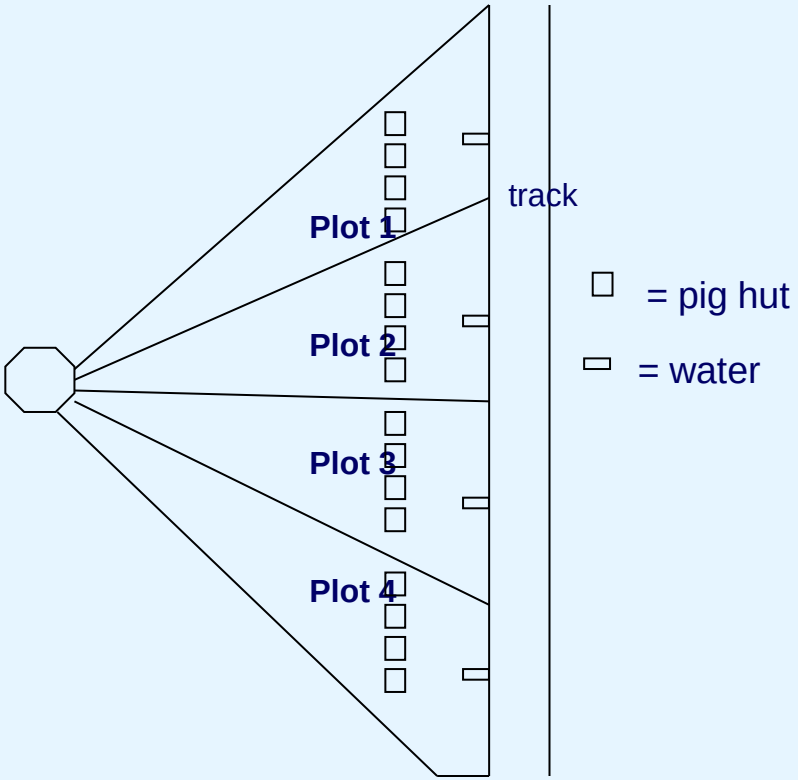
- Trough feeding
  - Soil N is high in feeding areas
  - Is this waste feed?

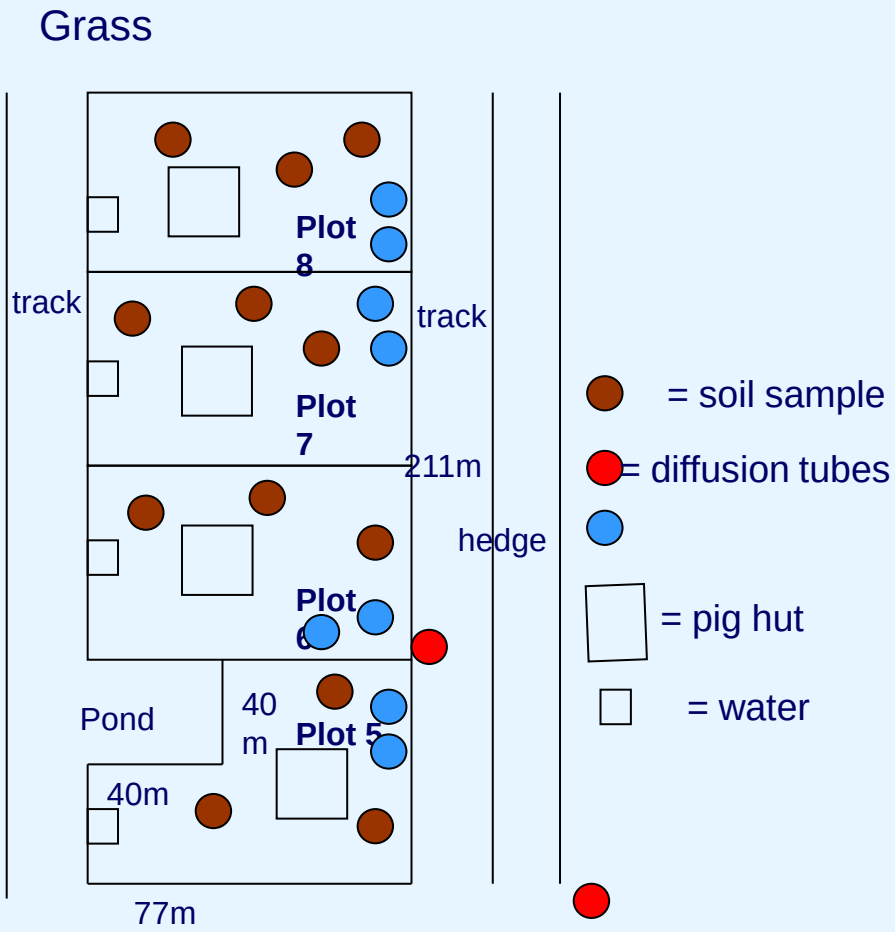


Soil nitrate-N in June



Commercial vs experimental layouts



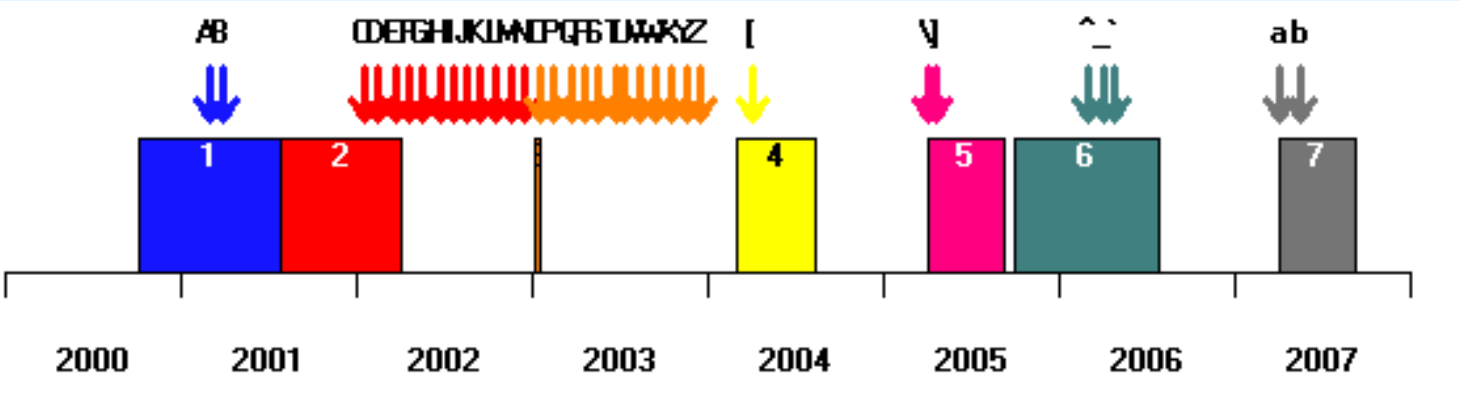


Rotation Modelling ECOPIG

a

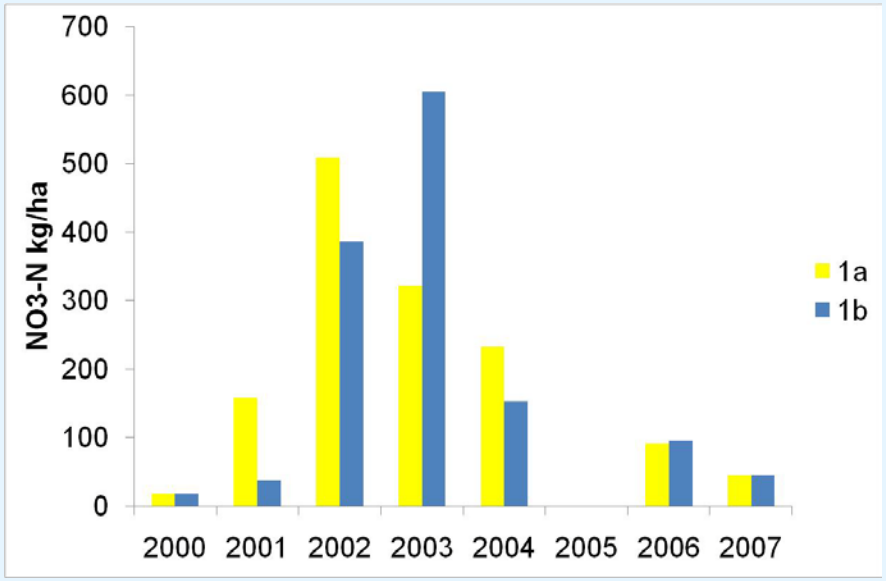
(1) w barley (2) pigs (3) pigs (4) w wheat (5) sugar beet (6) w wheat (7) potatoes The arrows indicate the applications of manure or fertilizer

b

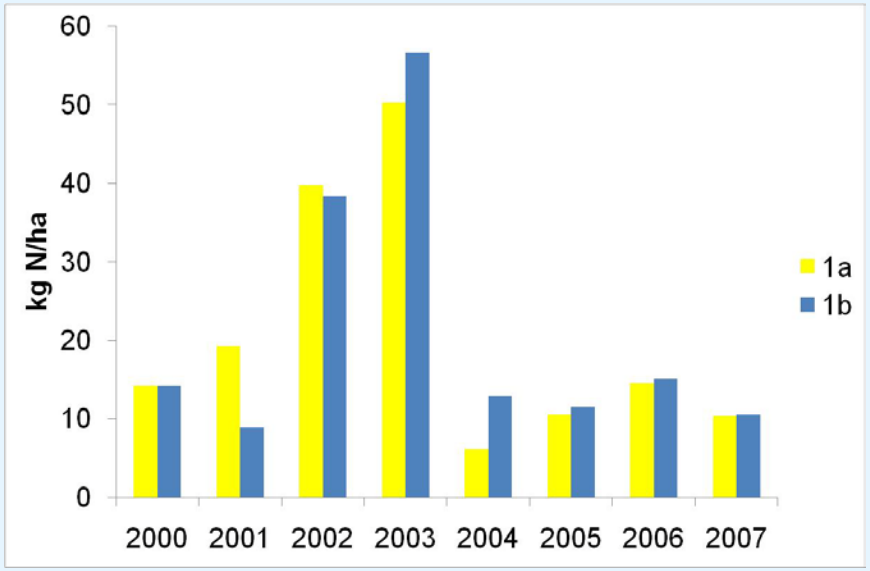


(1) w barley (2) barley stubble undersown with grass & pigs (3) pigs (4) sp barley (5) sugar beet (6) w wheat (7) potatoes

Results



Annual leaching losses



Annual denitrification losses

How well did this work?

The good bits

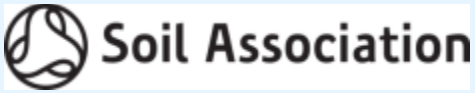
- A (mostly) happy voluntary marriage!
- Strong leadership
- Specific objectives
- Development of innovative solutions
  - influencing animal behaviour
- Truly transdisicplinary

Challenges

- Some conflict between industry and science
  - priorities
  - experimental design
- Costs difficult to predict

Green Pig

Sustainable Livestock Production (SLP)



Green Pig: Overall Aim

To assess the potential of using **home grown legumes** in **growing/finishing pig diets** in order to **reduce** the **environmental burden** of pig production in the UK

- Joint project between **plant breeders, crop growers**, **pig nutritionists** and **pig producers**





Protein sources in UK pig diets

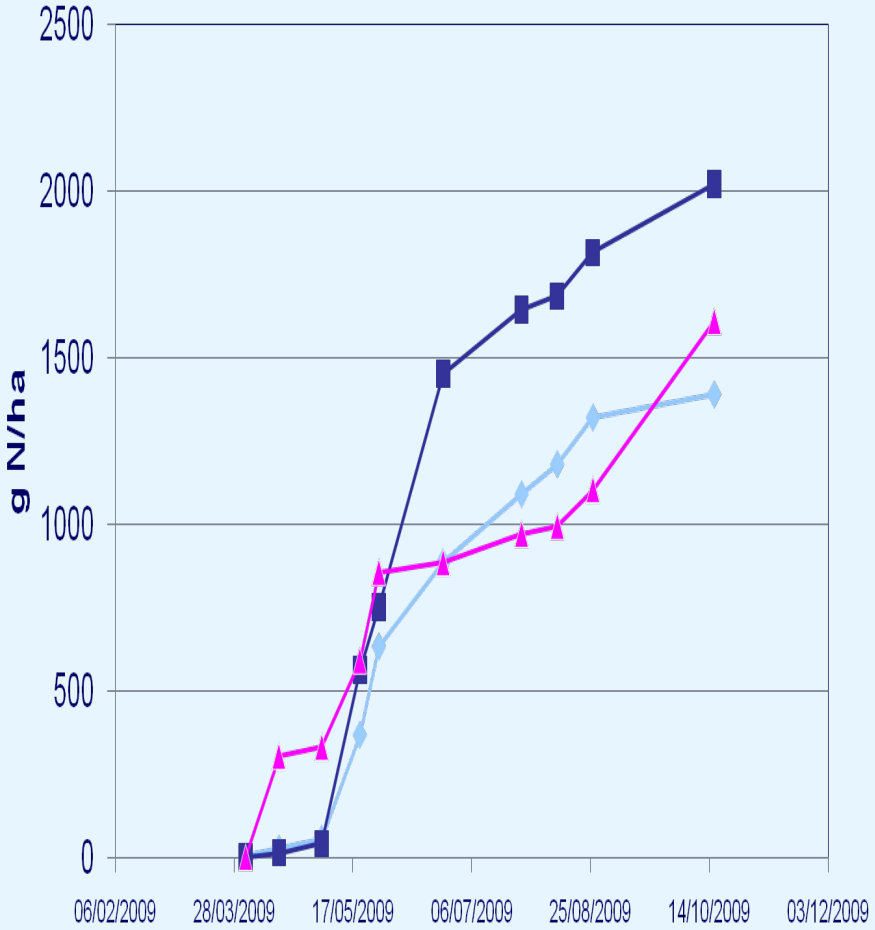
- Several feedstuffs are used as protein sources:
  - Oilseed by-products (rapeseed meal, soybean meal and sunflower meal)
  - Milk products (whey, skimmed milk powder)
  - Animal products (fishmeal)
  - Pulses (peas, faba beans)
  - Cereals (maize gluten feed but also wheat, barley)

Looking for alternatives?

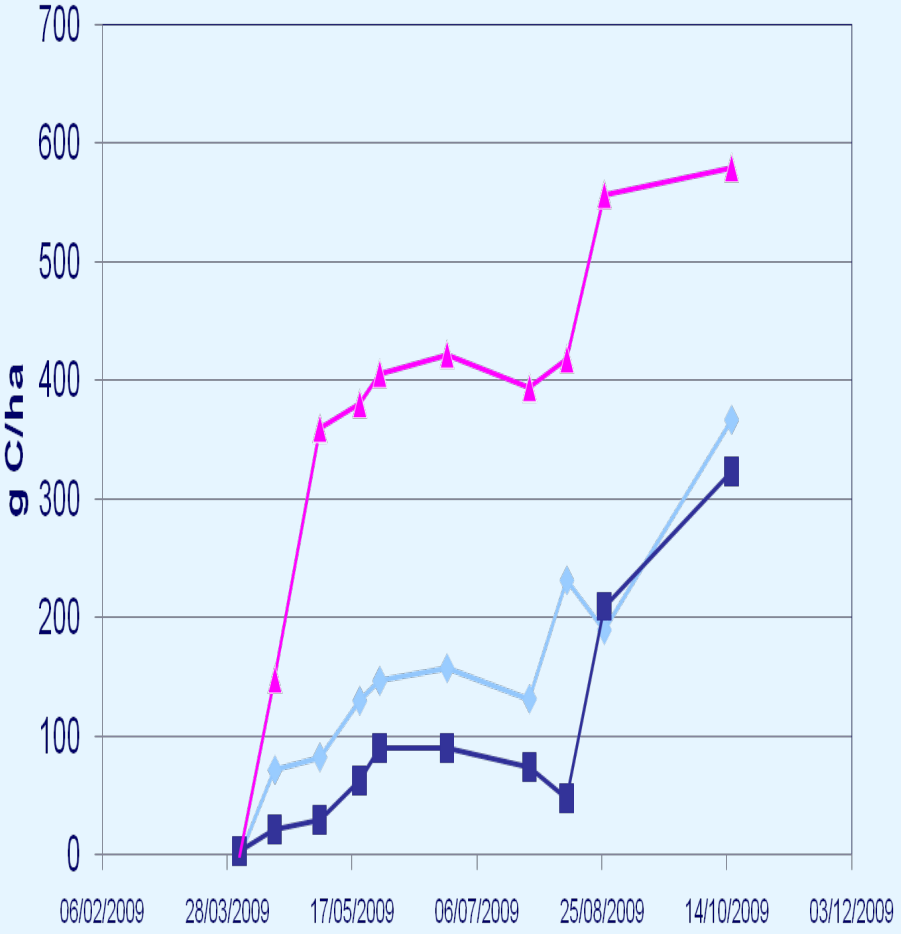
- Challenges for Soya Bean Meal use
  - Feed miles (main imports from Brazil, Argentina)
  - GM confusion (Brazil: non-GM; Argentina: GM)
  - Deforestation
  - Dependency on import
  - Pollution potential
- Potential to use home grown pulses as an alternative

- All else being equal, replacing UK SBM supply for pigs (2007) would have required ~500,000 tonnes of pulses

Variety matters – bean variety trials, Aberdeen 2009

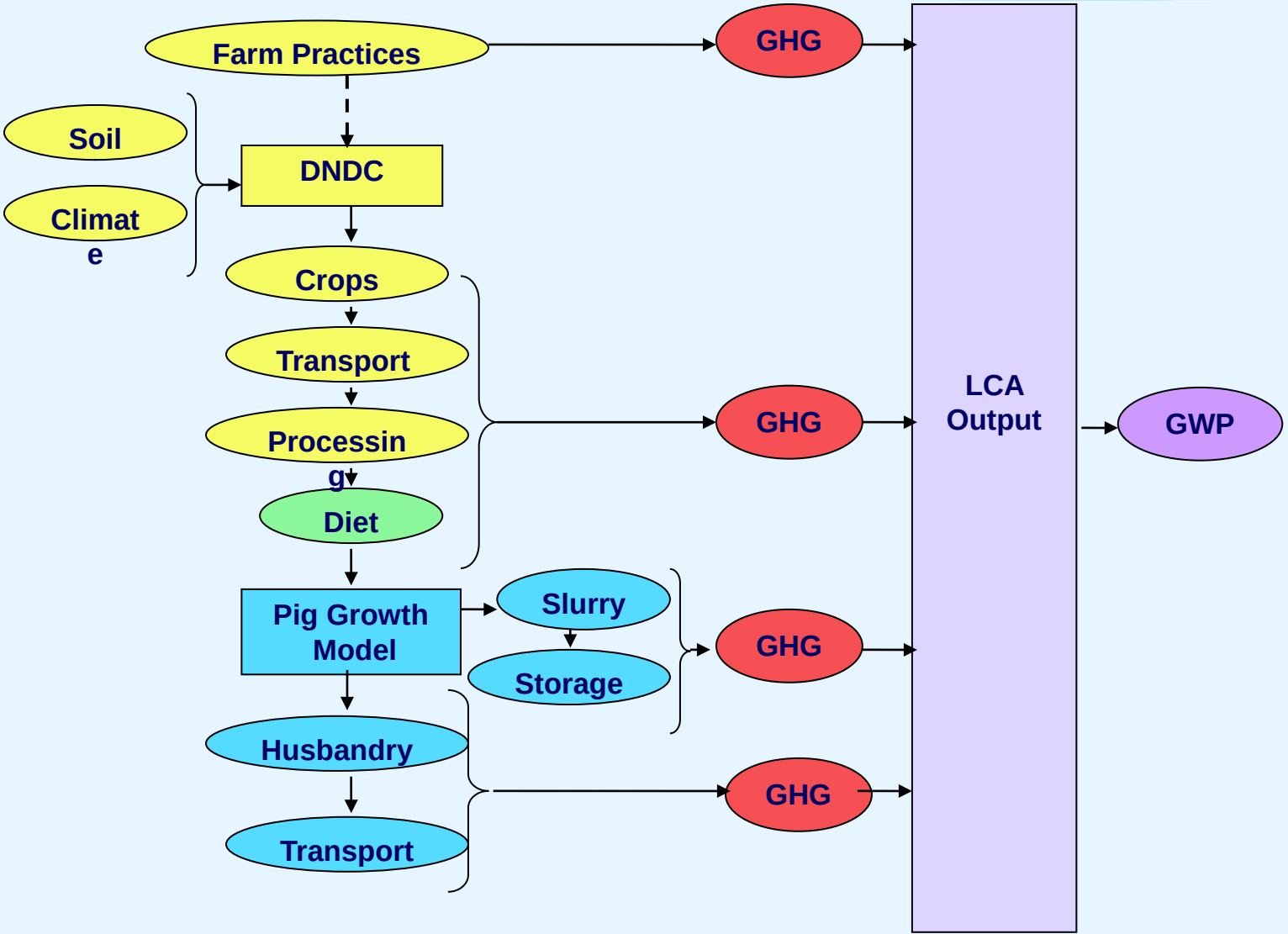


N_2O



CH_4

LCA from GreenPig



How well did this work? (ongoing)

The good bits

- Strong leadership
- LCA approaches are useful for integration within the production chain

Challenges

- Sometimes difficult to meet industry expectations (priorities)
- Crop and animal science have operated separately

Marginal Abatement Cost Curves

- An approach to working out the costs of mitigation options for climate change issues e.g. nitrous oxide emissions
- What are they?
- How much will they cost?
- Are they practically feasible?

Introduction to MACC

Generate initial list of 97 measures

Expert meeting: discuss and remove measures (a) likely to have very low additional abatement potential in UK or (b) unlikely to be technically feasible or acceptable to the industry. Some measures aggregated.

Interim list of 35 measures

Estimation of each measures' abatement rate and area of application; calculation of maximum abatement potential, based on expert interpretation and published data (e.g. Smith *et al* 2008)

Removal of measures with potential of <2% UK agricultural emissions

Short list of 15 measures

Costing exercise with experts

Modelling of measures impact of farm gross margins

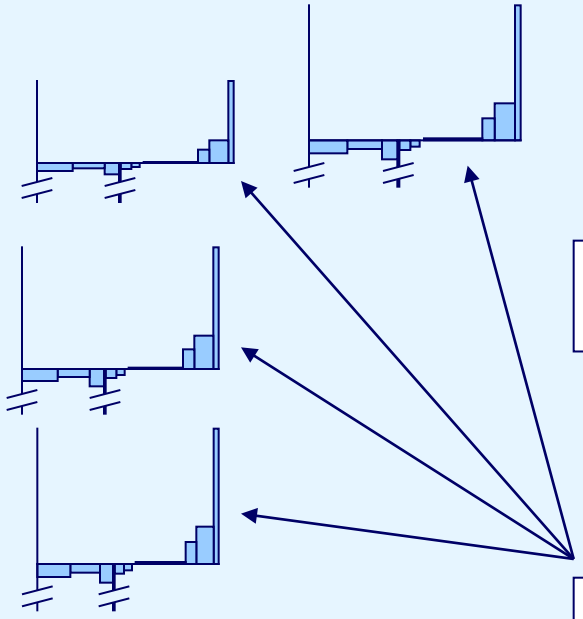
Stand-alone cost-effectiveness and abatement potential

Stand-alone MACC

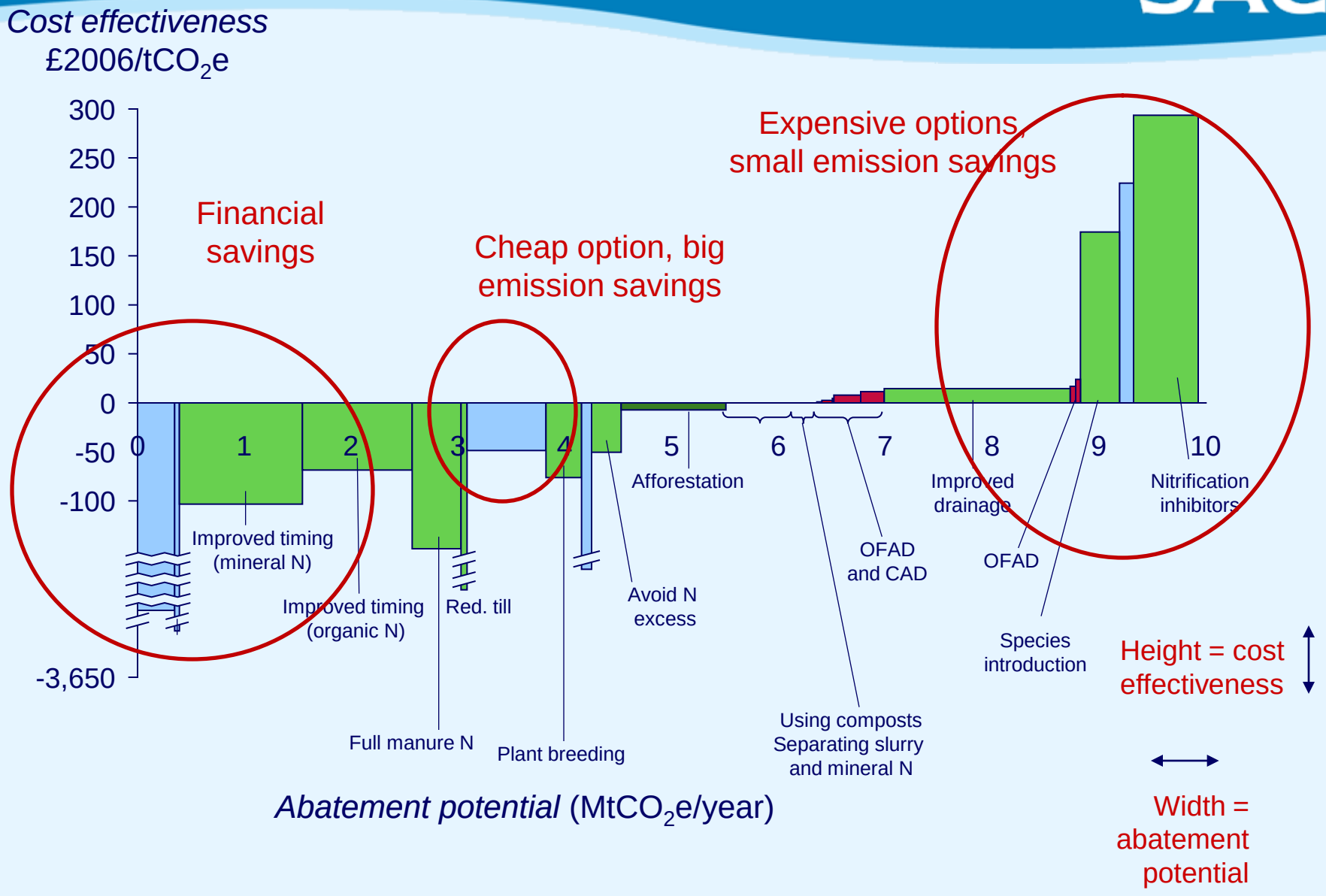
Recalculation of CE and AP based on interactions between measures

Combined cost-effectiveness and abatement potential

Combined MACC



Marginal Abatement Cost Curve (2022, CFP, 3.5%)



Results for crops/soils measures
(2022, CFP, 3.5%)

Measure	ktCO2e abated	CE [£2006/tCO2e]
Improved Timing, Mineral N	1,150	-103
Improved Timing, Organic N	1,027	-68
Fully accounting for manure N	457	-149
Reduced tillage	56	-1,053
Improved N-Use Plants	332	-76
Avoiding N Excess	276	-50
Using Composts	79	0
Separating Slurry and Mineral N	47	0
Improved Drainage	1,741	14
Species Introduction	366	174
Nitrification inhibitors	604	293
Controlled release fertilisers	166	1,068
Reducing N Fertiliser	136	2,045
Adopting Systems Less Reliant On Inputs	10	4,434
Biological fixation	8	14,280

How well did this work?

The good bits

- Big success with policymakers
- Excellent stakeholder buy-in (range of stakeholders)
- Project has won UK GreenGown award
- Good team who really communicate

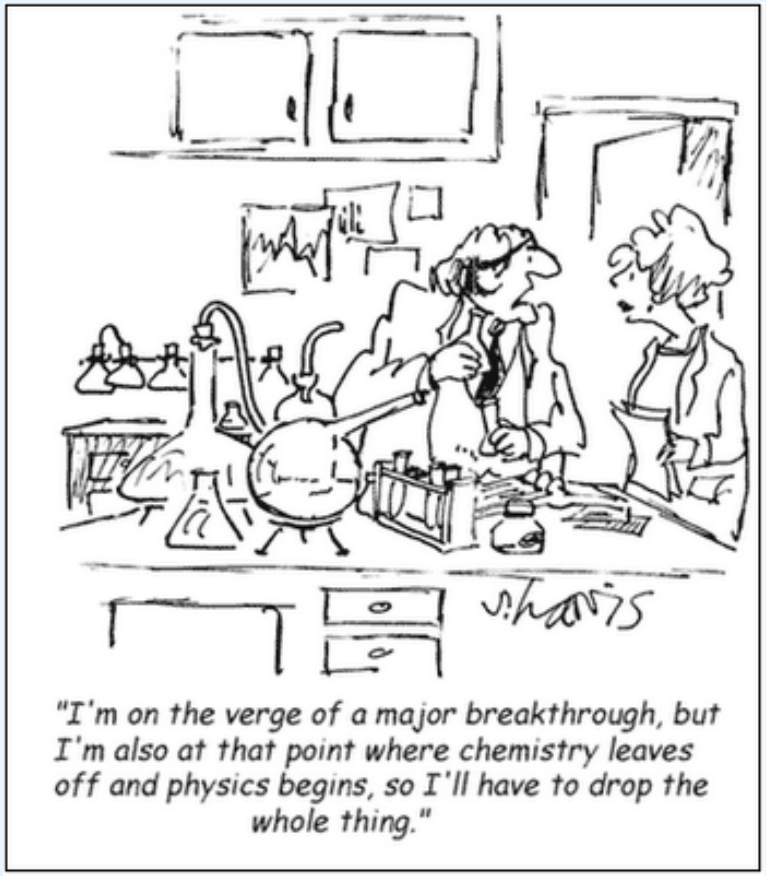
Challenges

- Not an exact science!
- Natural scientists seem to worry much more about the detail than economists!
- How to improve the estimates with biophysical models

Analysis of projects (blob diagram??)

	Sustainable crops	ECOPIG	GREENPIG	MACC
Interdisciplinary	x	xx	xx	xx
Transdisciplinary		xx		xxx
Integrate experimental and models	xx	xx	xxx	x
Integrate scales	xxx	xx	xxx	xxx
Stakeholder integration	x	xx	xx	xxx

Attitudes….



- It’s scary/uncomfortable/ needs a different sort of brain
- Some people just aren’t interested!
- “Only my bit is important”
- “The technical stuff is all done, so we should focus on economics (or vice-versa)”

Frog-fusion!


RIBBIT
CLICK
KA-POW
FUN FACT: Ex-particle-physicists make the worst biologists.

Barriers….

- Cultures and attitudes (challenging beliefs)
- Language and communication
- Publication
- Recognition and reward
- Investment of time and resources
- Critical mass
- Leadership

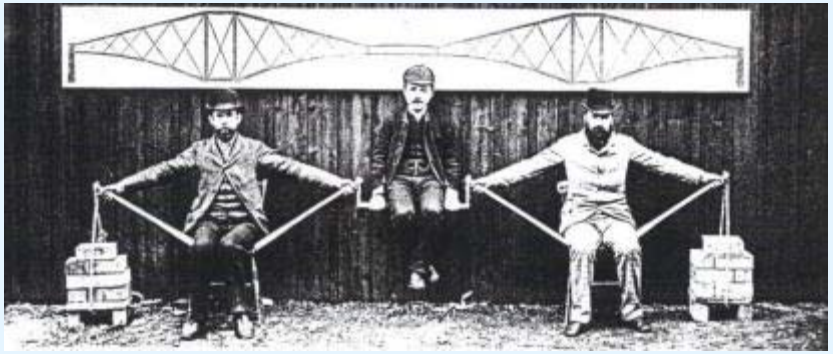
"I understand they're going to connect them. The Provost ordered it."

(National Academy of Sciences, 2005)

Lessons for the futures

- It is pleasure but sometimes there is pain!
- Pain can often occur during the “teething” stage
- “Time spent in reconnaissance is seldom wasted” General Montgomery
- Agree the boundaries
- Don’t underestimate how long building a good team can take
- It’s a chance to expand your mind not blow your mind…….

Like building a bridge?



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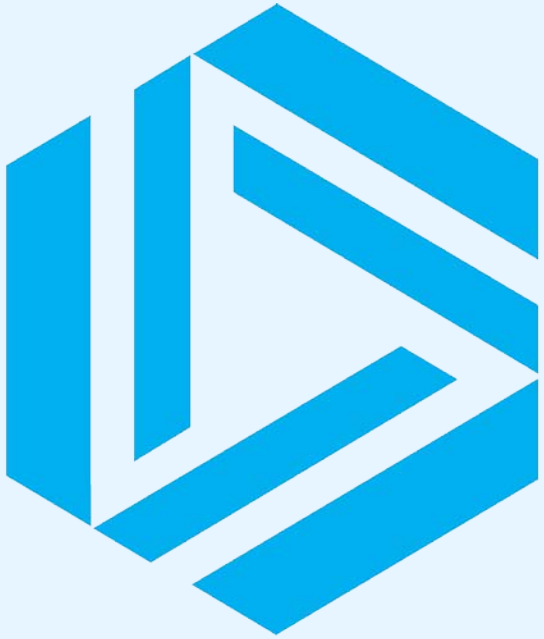

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Success through Knowledge