The importance of manure and cropping systems for P management – how do we reach long term sustainability?

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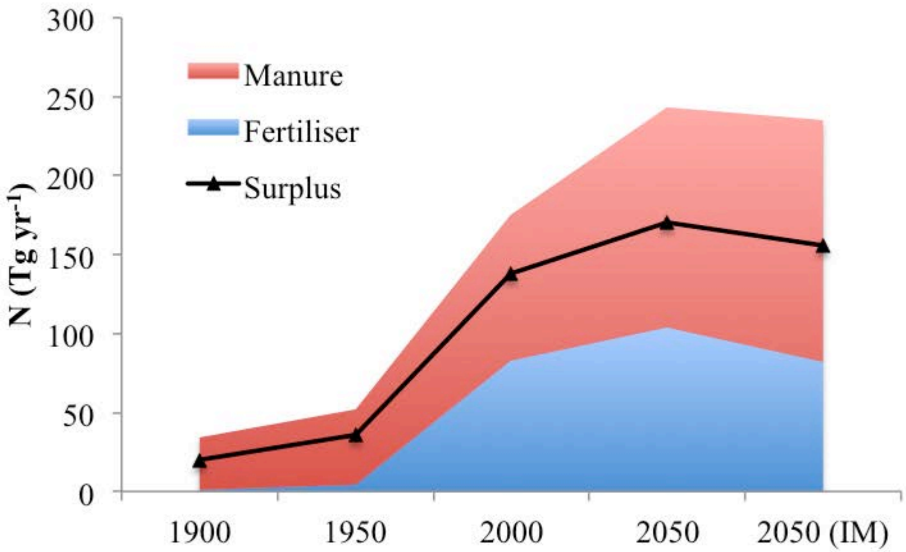
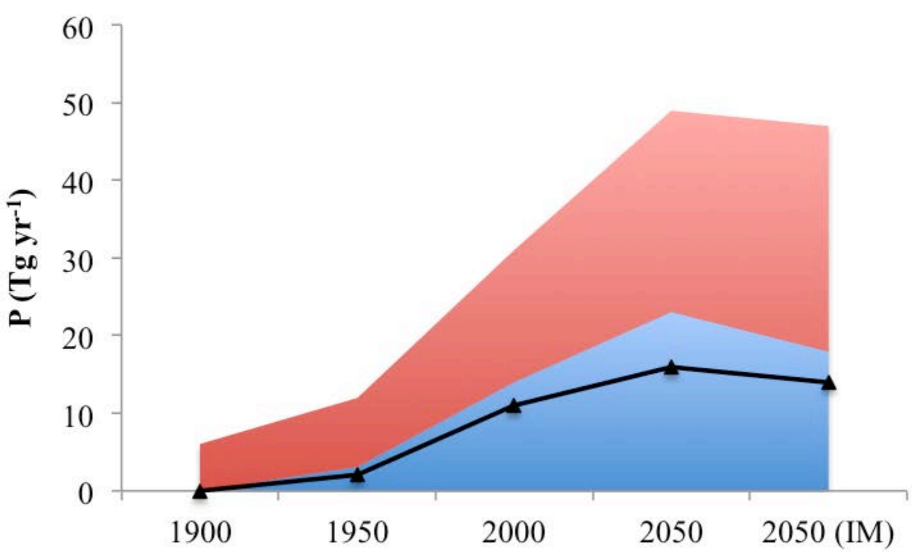
Issues with Manures

- Large volumes due to high demand for meat – and range of materials expanding
- Policy drivers now in place to encourage land application – a resource with multiple benefits
- Often applied in excess of requirements leading to soil P accumulation
- Potential substitute for fertilisers – more highly valued than ever before
- Must be managed for effective utilization and environmental protection

Global Nutrient Dynamics





Rapid expansion after 1950 and further increases to 2050.

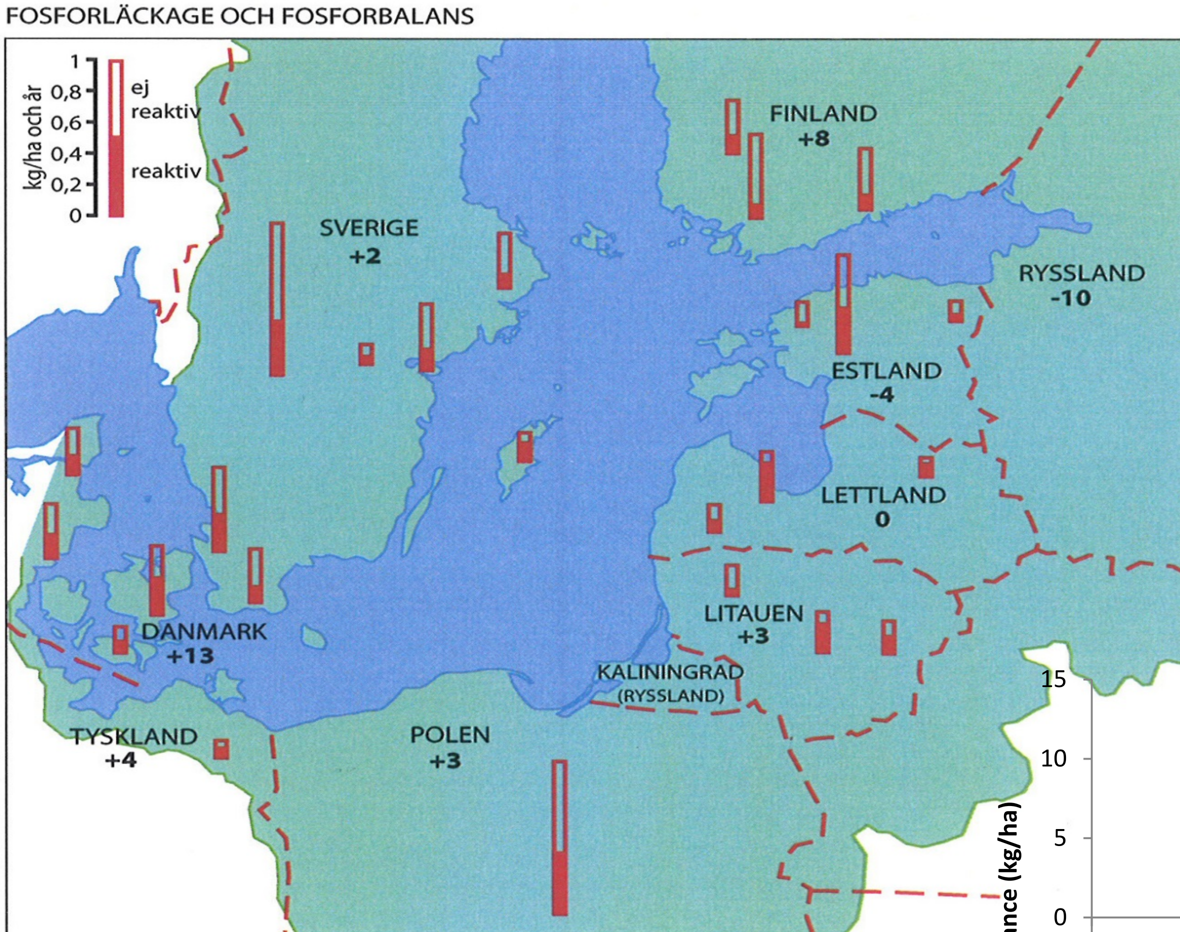
Inputs of manure nutrients exceed those of fertiliser inputs.

100% substitution of manures for fertilisers would remove the P surplus (but not the N surplus).

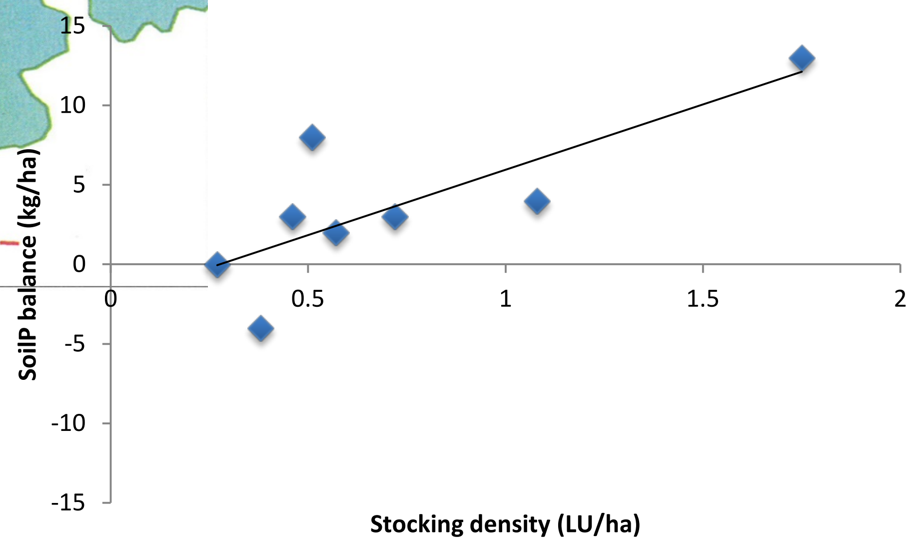
Scenario analysis predicted that better integration of livestock and cropping systems is the best way to reduce fertiliser P use.

Bouwman et al. 2011

Soil P Balance – Baltic Sea

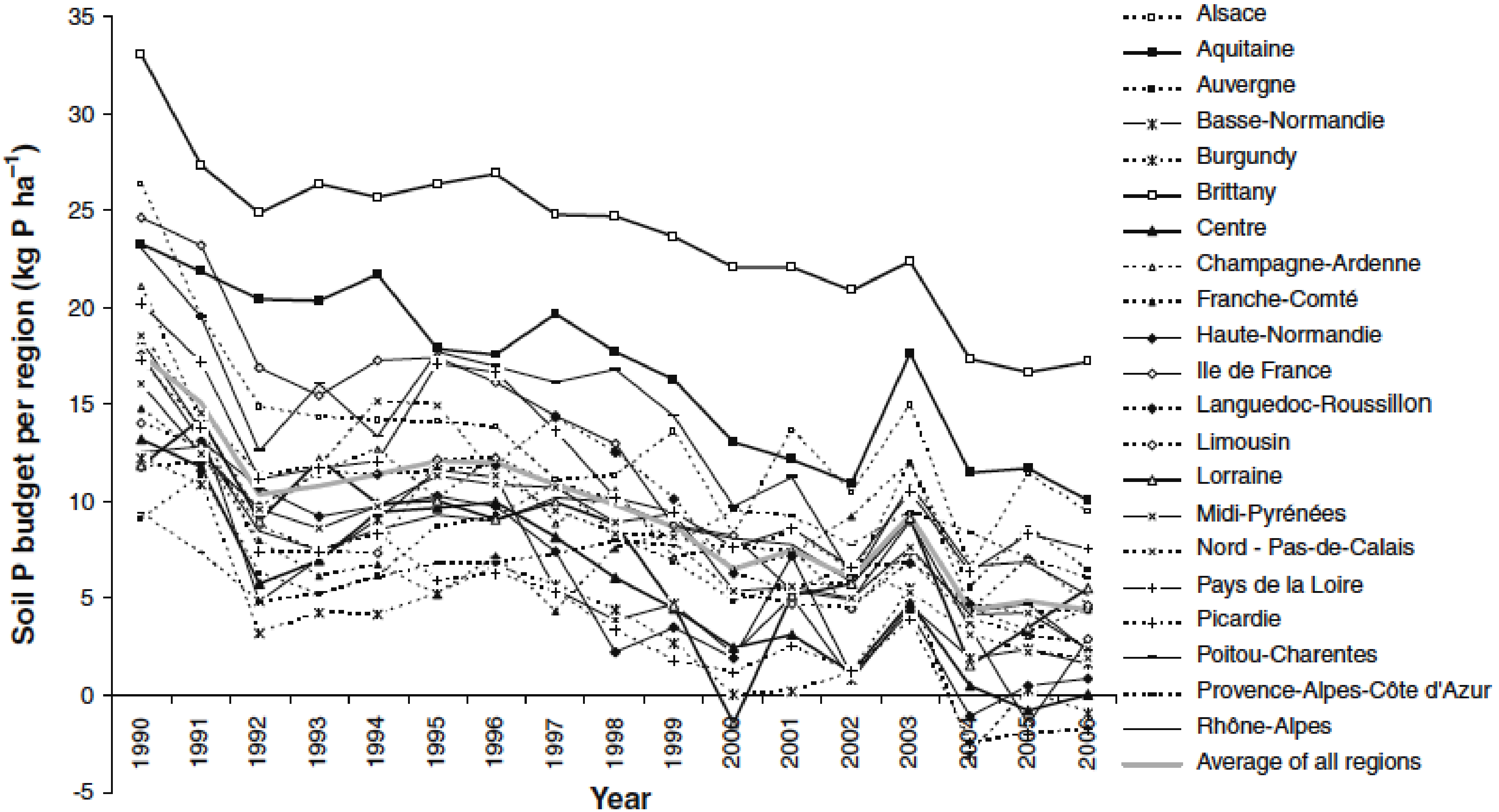


Export of particulate P (filled bars) and dissolved reactive P (unfilled bars) from small agricultural streams in the different countries.



(Ulén et al., 2012)

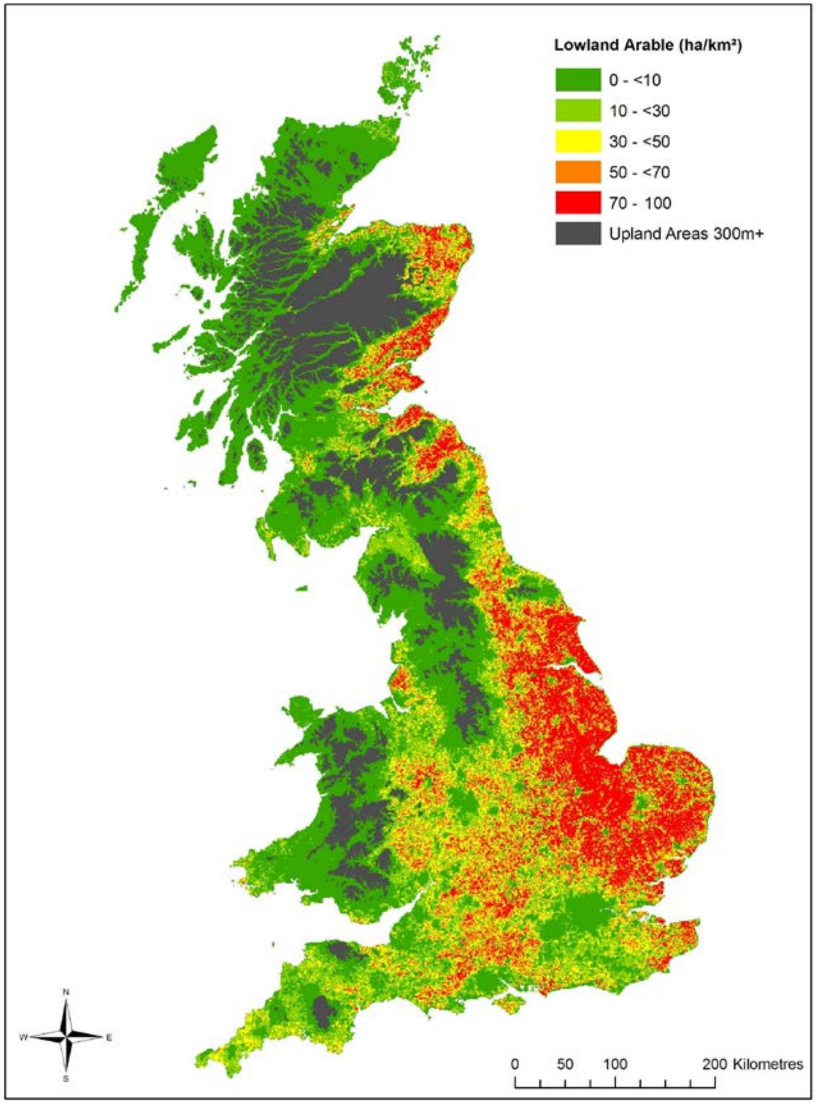
Large Regional Variation



Agriculture's impact on regional P flows occurs largely through livestock densities!

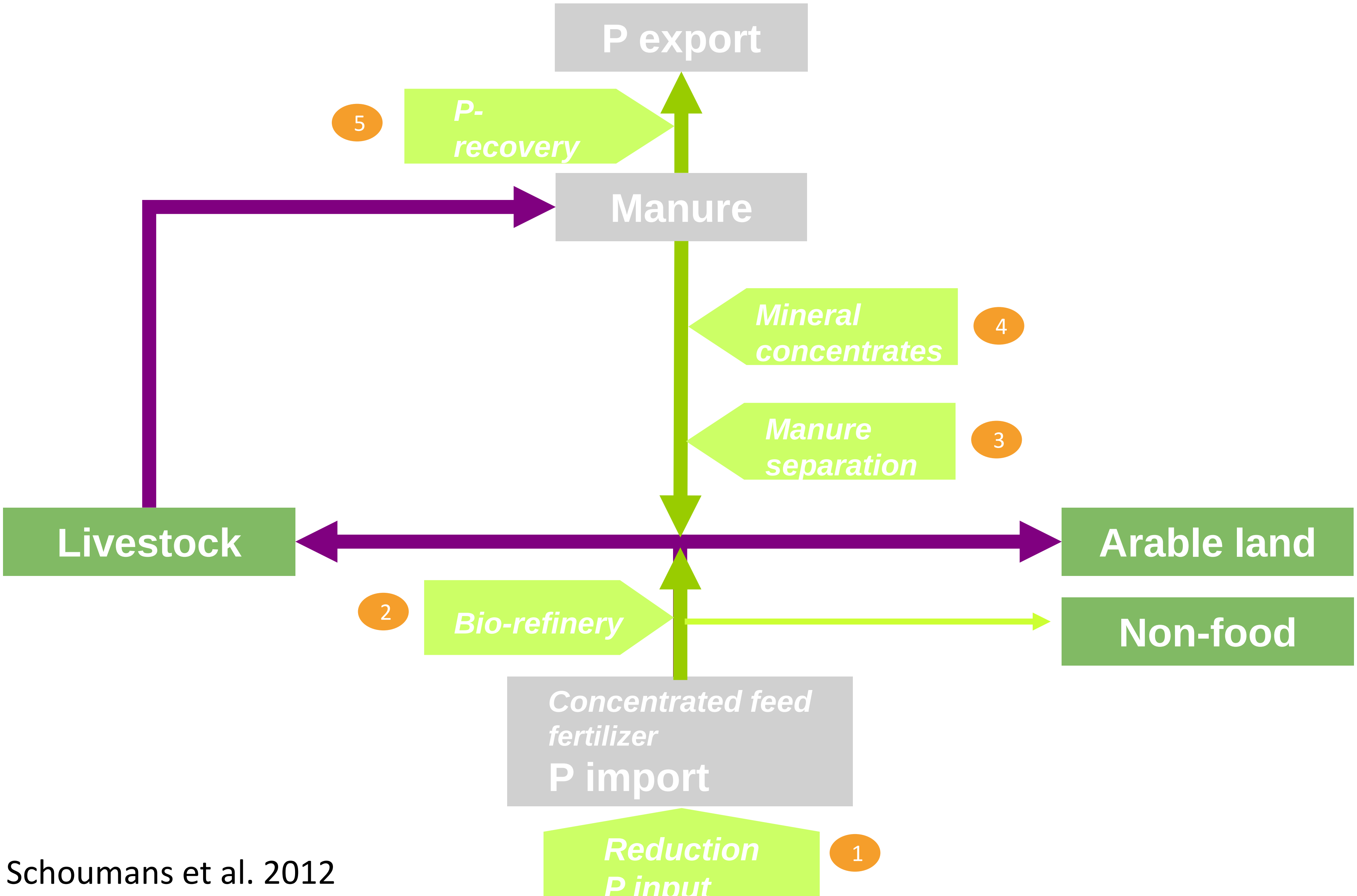
Senthilkumar et al. 2012

Land Use Distribution in the UK



- Only 20% of arable crops receive livestock manure each year
- 2.8 M tonnes of manure must be recycled from west to east to balance P demand (Bateman et al., 2012)
- Spatial disconnects:
  - arable to livestock
  - rural to urban

Technological Innovation



Schoumans et al. 2012

Manure Utilization on the Farm

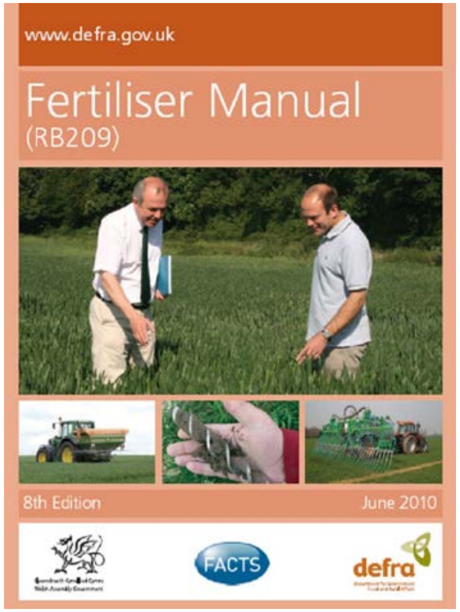
Constraints

- Variable composition and quality
- Low confidence in nutrient release rates
- Difficulties of uniform/precise application
- Costs of storage and transport
- Unbalanced supply of NPK for crops
- Rate restrictions in some areas (e.g. NVZs)
- Public perceptions of contamination
- Stringent regulations for land application of wastes

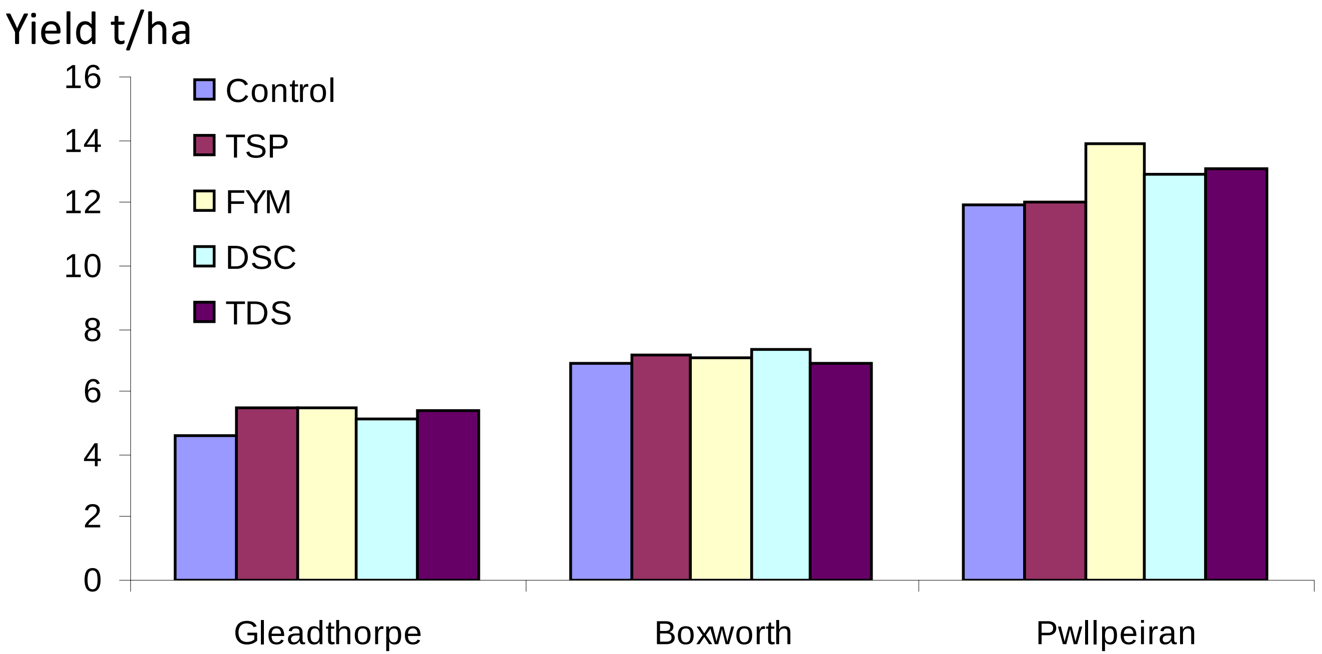
Dilemma: Manure is a valuable sustainable renewable ***Resource*** but many barriers to overcome to improve utilization

Improving Utilization on the Farm

- Accounting for total nutrient content
- Matching supply with demand (N v P)
- Exporting what cannot be utilised
- Maximising efficiency of use (timing)
- Reducing losses to water



Demonstrating Manure Fertiliser Value



6-yr trials

P Index 2/3

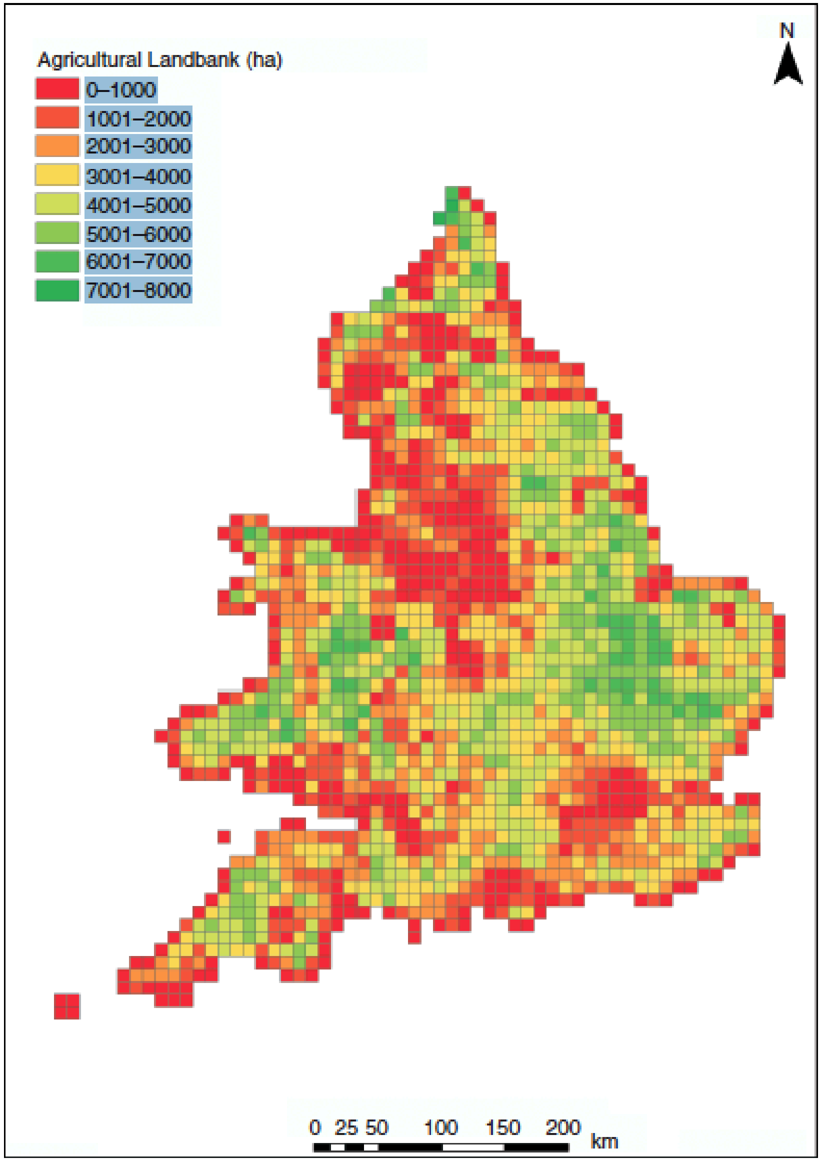
140 kg P_2O_5/ha

Manures are equally effective sources of P over a rotation provided background soil P is adequate

Livestock manures have generally greater P availability than other manure types (Oenema et al. 2012)

Use manures to build-up the soil fertility bank and use inorganic fertilisers where P availability more critical

ALOWANCE – Manures Landbank



Estimates the allowable landbank for spreading of ***new*** wastes based on physical and regulatory constraints:

Used to estimate landbank shortfalls in different areas and the length of time it will be available.

Available landbank in E&W is 5.1M ha or 55% of total productive land

Nicholson et al. 2012

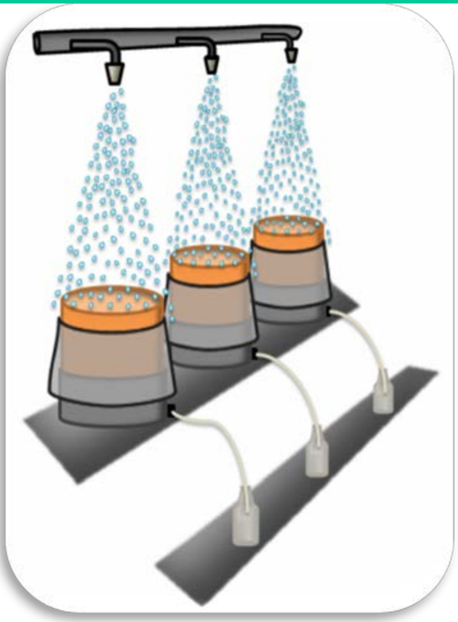
Manure Incorporation Effects

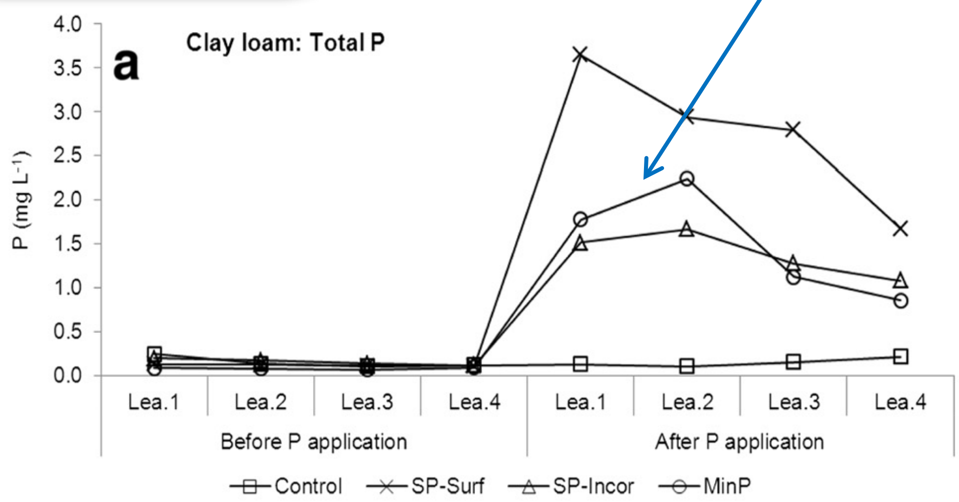
+

Surface

Incorporation

+

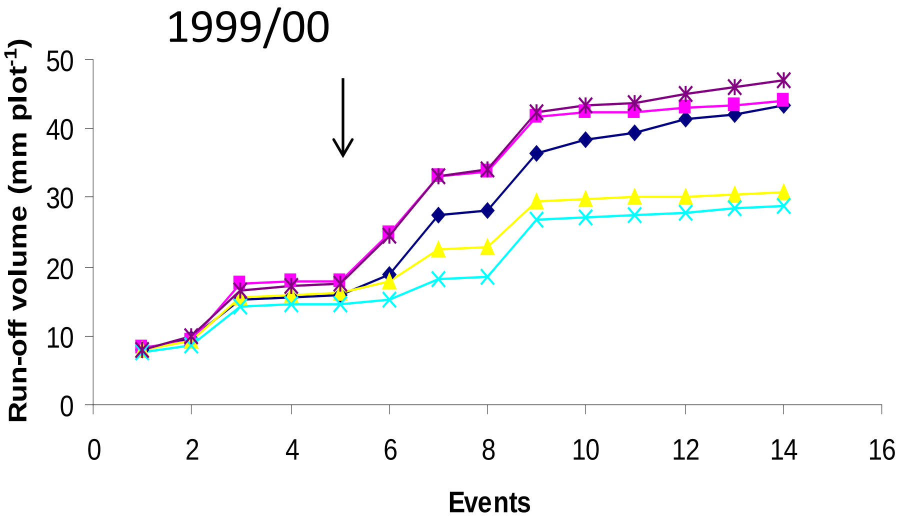


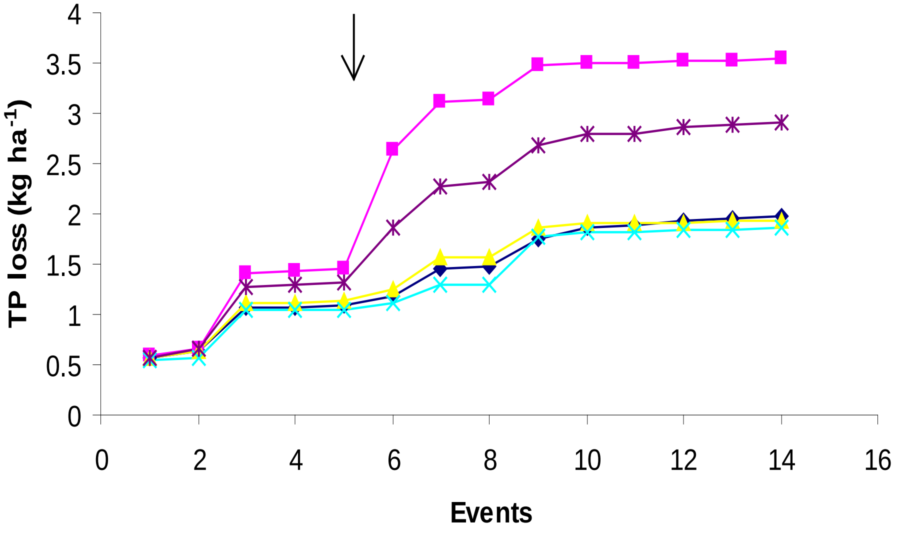


Incorporation of pig slurry reduces the risk of P leaching (64%) from structured soils but not completely!

Liu, J. et al., 2012

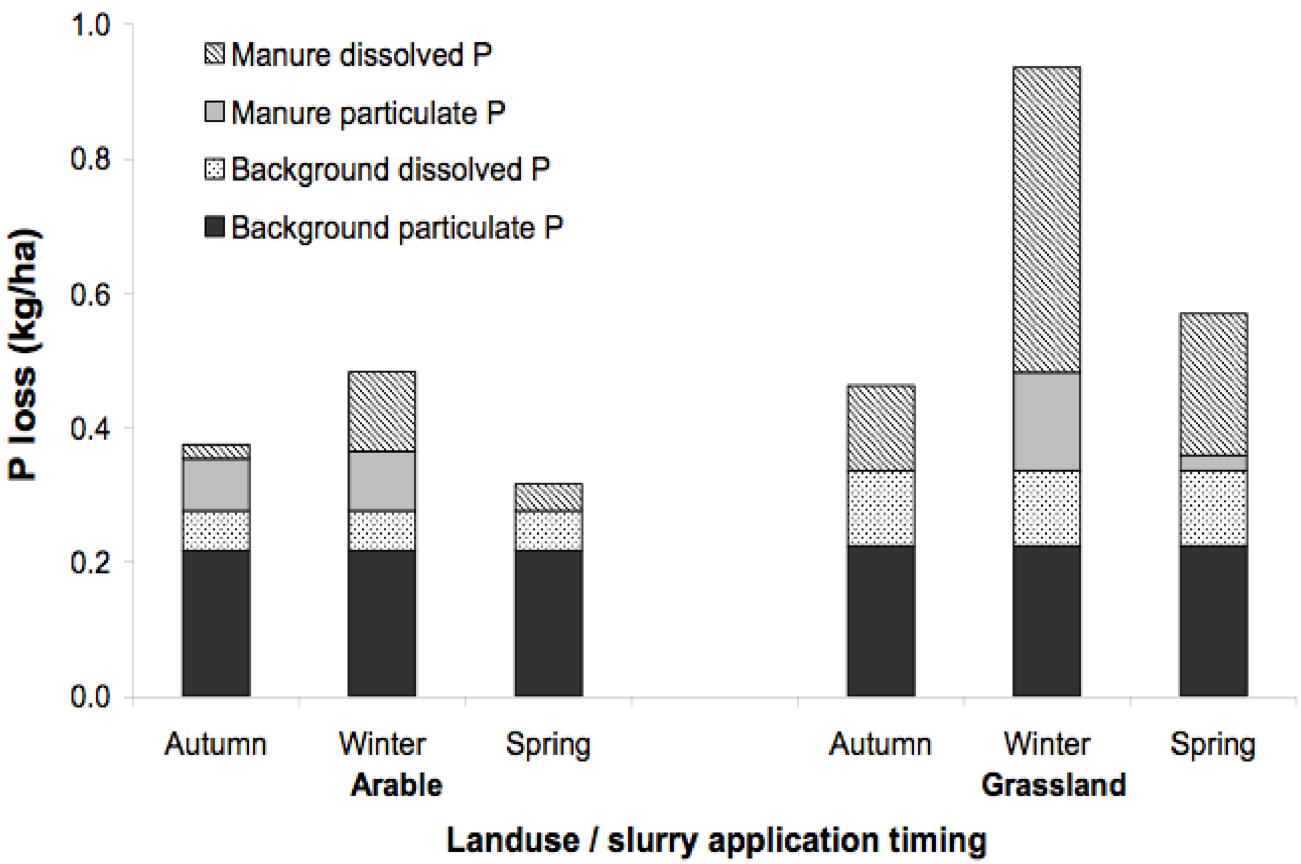
Spreading The Risk





- Incorporation of manures very effective
- Multiple manure applications spread the risk but still greater than the control

Manure Management



Brimstone 2003-2006

Drained clay soils

Cattle slurry 20 kg P/ha
Soil Olsen P – 6 mg/L
Mean of 3 years

Export greater from grass than arable land

Largest losses when applied to wet soils in winter and spring

Sagoo et al. - accepted

Managing the Risk

Brimstone Farm

Timing	NO_3-N	NH_4-N	P	Compaction (X compliance)
Autumn	★★★	★	★	★
Winter	★★	★★★	★★★	★★★
Spring	★	★★	★★	★★
Summer	★	★	★	★

★ Low risk; ★★ Medium risk; ★★★ High risk

Issues with Cropping Systems

- Intensification of cropping systems has led to loss of OM, soil degradation and erosion
- Widespread implementation of measures to control erosion but variability in effectiveness and side effects
- Precision farming capability expanding rapidly
- Different crop species have potential to conserve and recover soil P – designer cropping

Cropping Systems and Soil Erosion

- Agriculture is a major driver of soil degradation
- Key farming methods that have increased erosion include:

Over-exploitation of soils

Cultivation of marginal land

High sheep stocking densities on upland soils

Over-cultivation of lowland soils

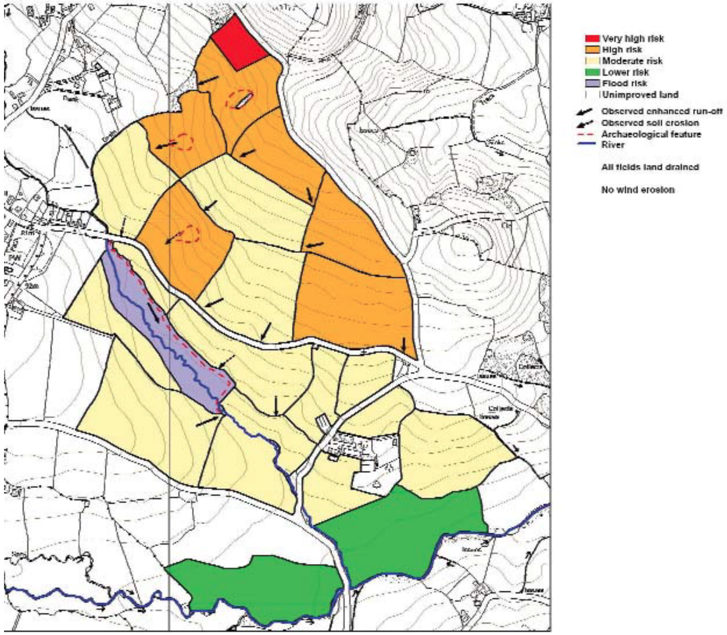
Removal of hedgerows

Soil compaction

Introduction of tramlines

Reducing Erosion Risk

- Identify vulnerable areas
- Provide crop cover
- Improve OM/soil structure
- Alleviate soil compaction
- Contour cultivation
- Manage tramlines
- In-field buffer strips
- Restrict livestock access
- Reversion to grass



Tillage and Liming Effects

Nutrient leaching (kg ha^{-1} year^{-1})

Tillage	no plots	PP	DRP	NO_3-N	OrgN*	N/P
Conventional ploughing	12	0.81	0.11	23.4	3.4	29
Structure limed	4	0.46**	0.13	26.9	2.6	50
Shallow tillage	8	0.93	0.12	22.4	3.0	24
Not ploughed, fallow	4	0.63	0.14	3.3**	2.9	8

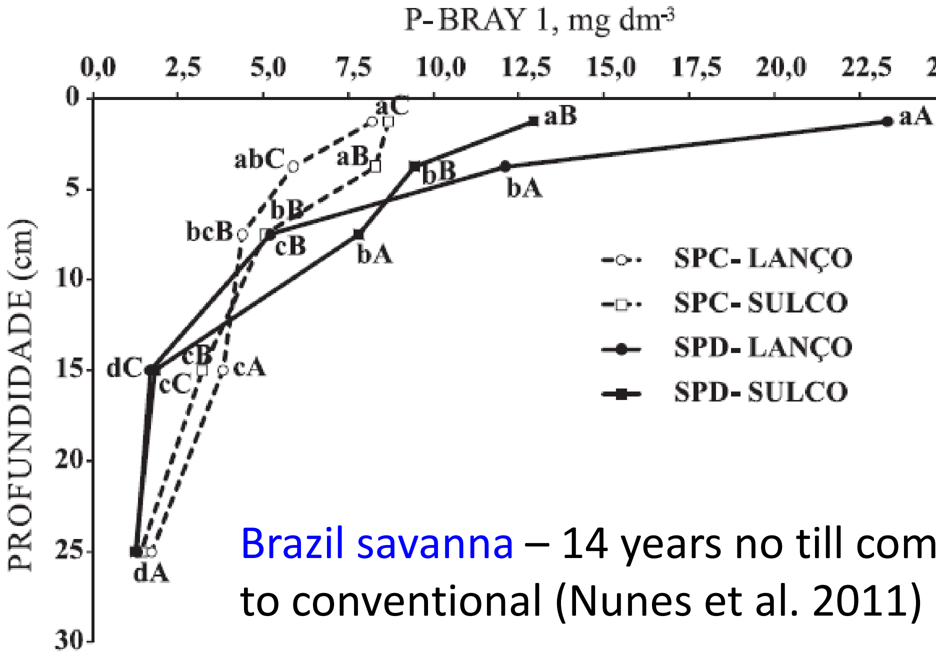
** Significant lower than conventional ploughed

(Svanbäck et al., submitted)

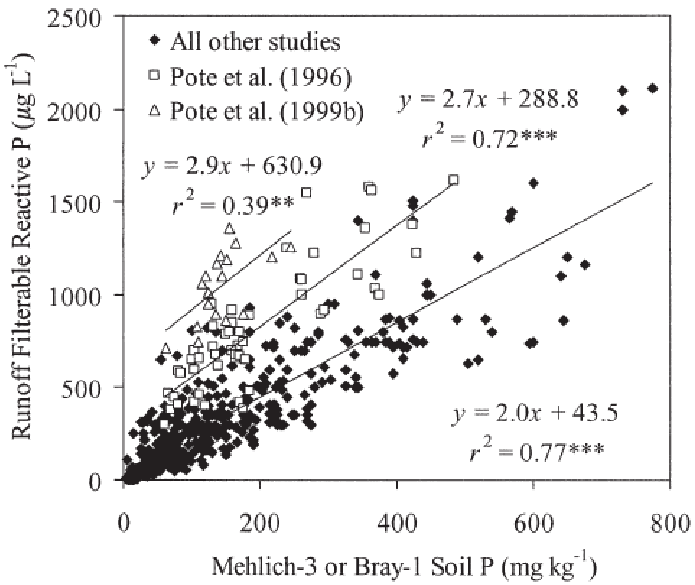
The Problem with Reduced Till

Soil depth (cm)	Soil test P (mg/kg)
0 – 2.5	60
2.5 - 5	49
5 - 12.5	34
12.5 - 20	26

Lake Erie - 1500 fields in reduced-till analysed to 20cm (Johnson, 2013)



Brazil savanna – 14 years no till compared to conventional (Nunes et al. 2011)

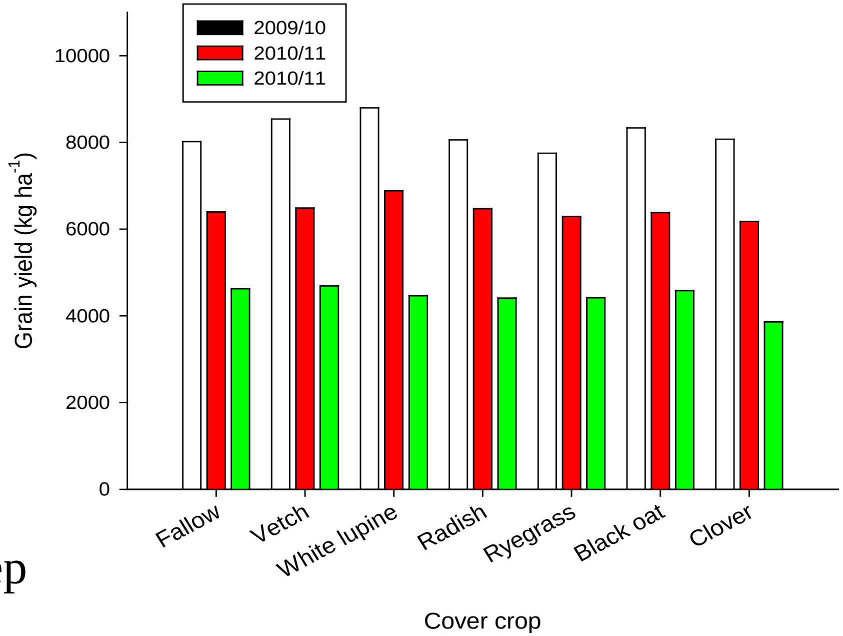


- Build-up of STP at the soil surface
- Link between STP and dissolved P (DRP) in runoff

Potential Benefits of Catch Crops

Photo: Erik Ekre

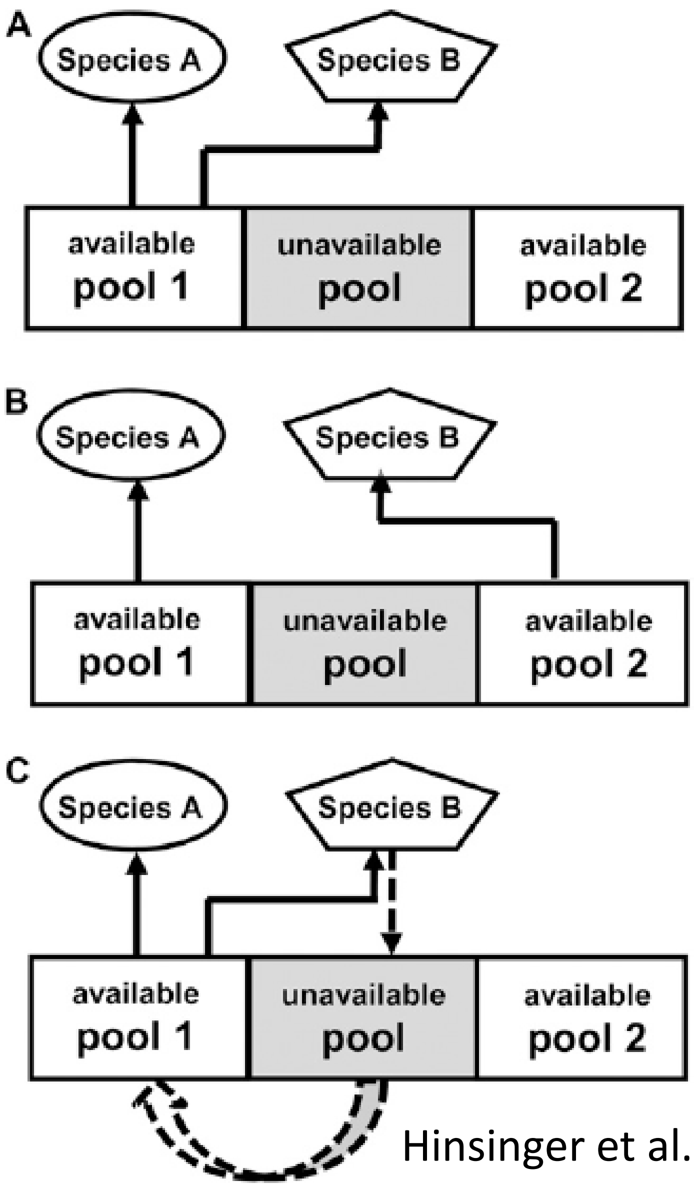
- Nutrient capture over winter (less N leaching)
- Soil protection
- Soil fertility
- Improve soil structure
- Weed suppression



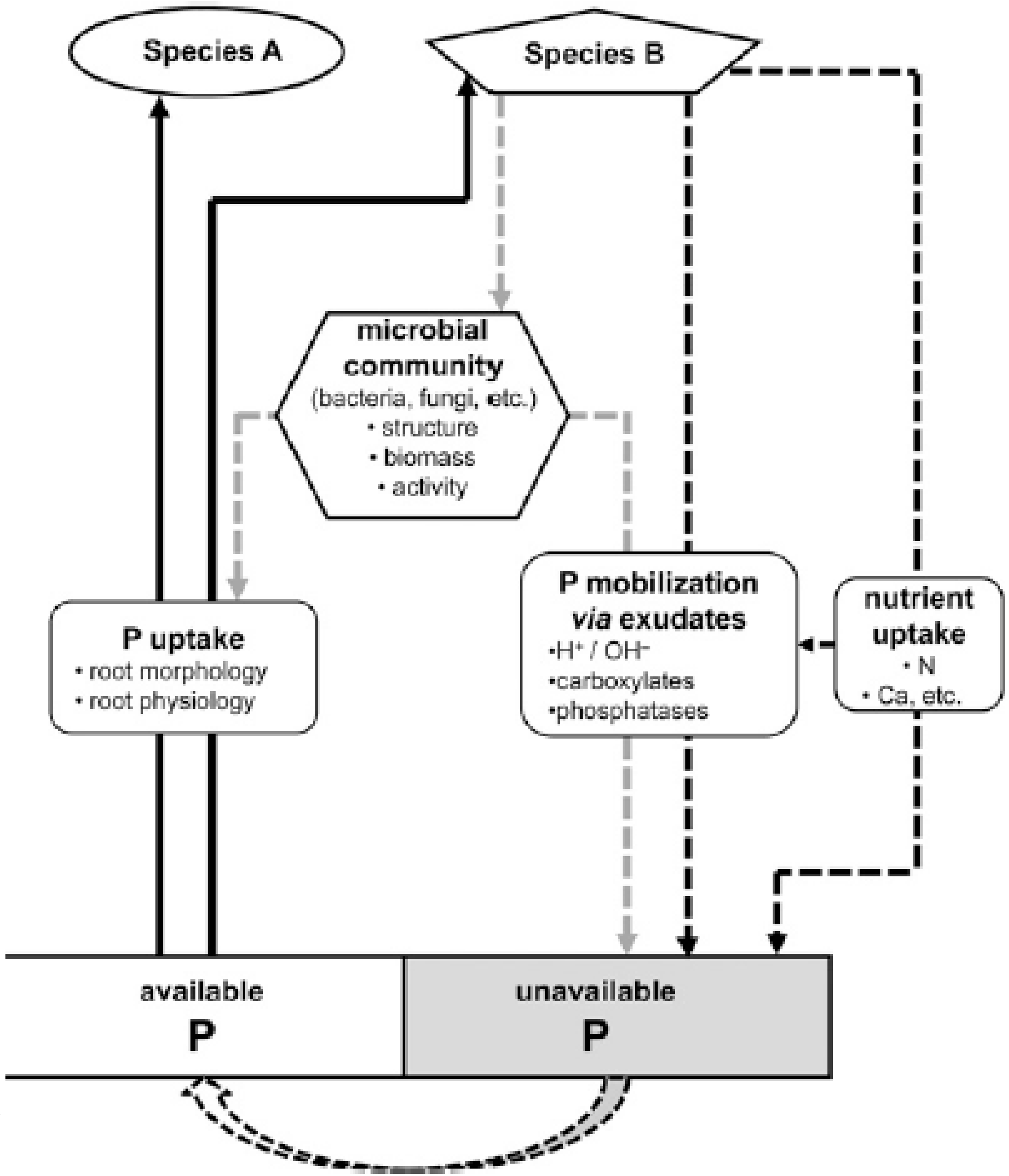
Take up variable amounts of P but no benefit to succeeding crop

Pavinato et al. – in prep

Phosphorus for Two?

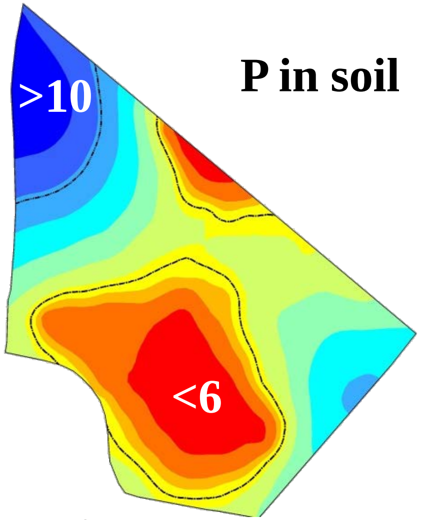


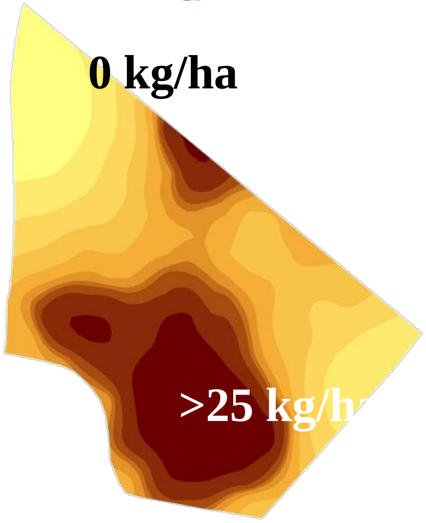
Hinsinger et al. 2011



Precision Farming

P in soil





Need of fertilizer

From Knowledge to Action

Self-evaluation of farms for
improved nutrient management

1. **Basic information about the farm**
   Soil mapping
   nutrient content of own manure

Main house Kłębek's farm Photo: E. Ryjak.

From Knowledge to Action

Self-evaluation of farms for improved nutrient management

2. Risk evaluation - walking around the farm

1. Basic information about the farm

soil mapping

nutrient content of own manure

Main house Kłębek's farm Photo: E. Ryjak.

From Knowledge to Action

Self-evaluation of farms for improved nutrient management

3. **Knowledge about possible mitigation options**

2. Risk evaluation - walking around the farm

1. Basic information about the farm

soil mapping

nutrient content of own manure

Main house Kłębek's farm Photo: E. Ryjak.

From Knowledge to Action

Self-evaluation of farms for improved nutrient management

4. **Possible actions**

3. Knowledge about the possible mitigations

2. Risk evaluation - walking around the farm

1. Basic information about the farm

soil mapping
nutrient content of own manure

Main house Kłębek's farm Photo: E. Ryjak.

Conclusions

- Fundamental need to close the P cycle using 4R strategy
- Meat demand will drive larger manure volumes
- Manure has multiple benefits (not just P) but some conflicts in P-rich areas
- Designer cropping has potential to conserve and recover soil P
- Integration of manure/cropping needed but how and at what scale?

Conclusions

- Nutrient accounting on farm essential - export
- Improve precision and efficiency on the farm
- Reduce losses by managing the risk
- Must consider pollution trade-offs - models
- Knowledge transfer/advisory tools still key