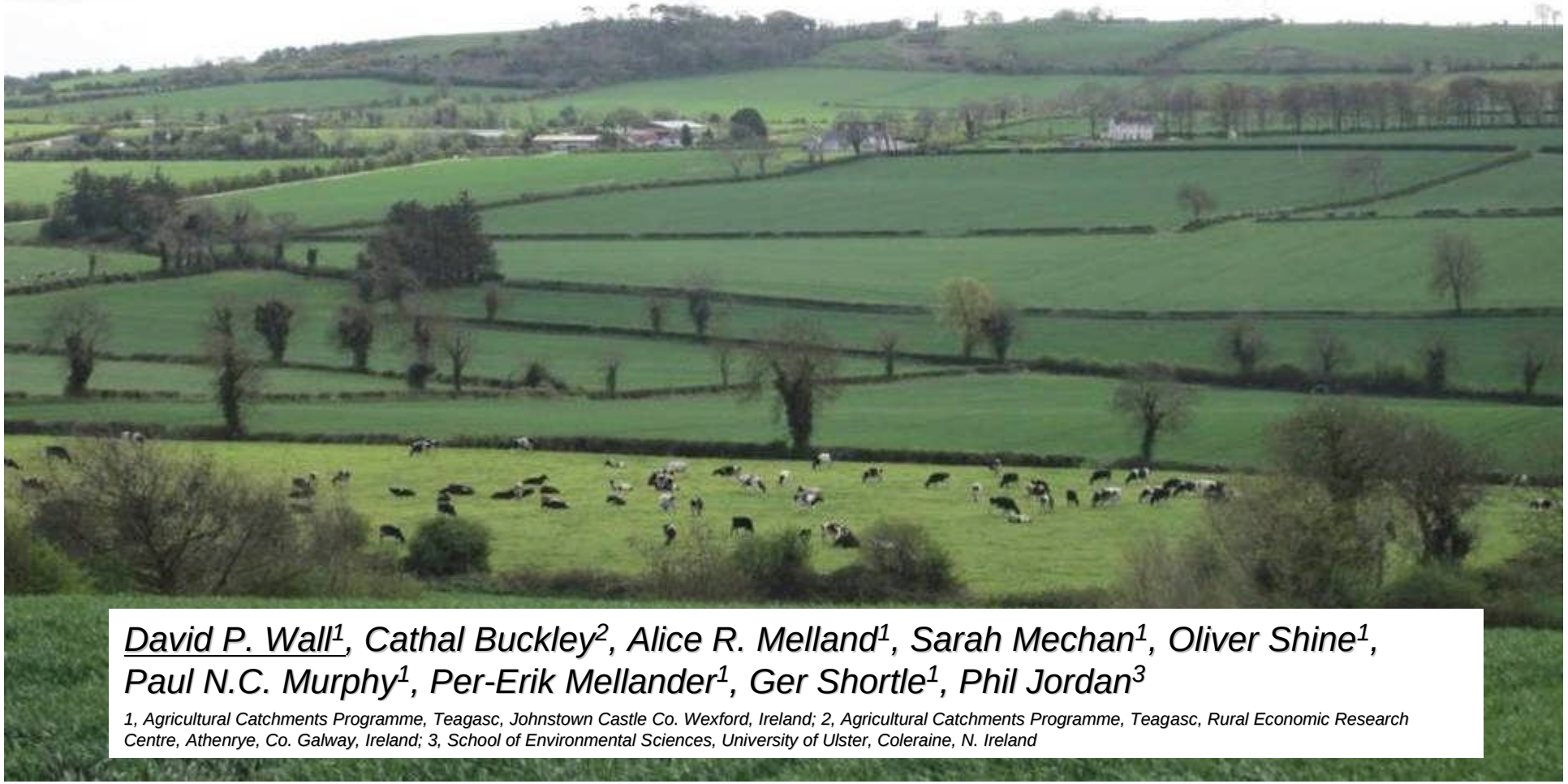
# Evaluating nutrient management regulations at different scales in agricultural catchments in Ireland



*David P. Wall[1], Cathal Buckley[2], Alice R. Melland[1], Sarah Mechan[1], Oliver Shine[1], Paul N.C. Murphy[1], Per-Erik Mellander[1], Ger Shortle[1], Phil Jordan[3]*

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The Irish Agriculture and Food Development Authority

# Evaluating nutrient management regulations at different scales in agricultural catchments in Ireland

- Legislative constraints on nutrient use for agriculture in Ireland
- Approaches to evaluating mitigation measures for nutrient loss
  - Experimental scale
  - Spatial scale
  - Temporal scale
- Conclusions
- Implications for policy and expectations

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## EU Nitrates Directive National Action Programme (NAP)

- Implemented in Ireland on a whole-territory basis
- Constrains N & P applications of inorganic & org. fertilisers
- Caps livestock intensity at 170 kg Organic N $ha^{-1}$
- Supports a derogation up to 250 kg Org. N $ha^{-1}$
- Mandatory on-farm organic manure storage requirements
- Separation of clean and dirty water
- Ploughing restrictions and green cover establishment
- Farm herd and nutrient management records

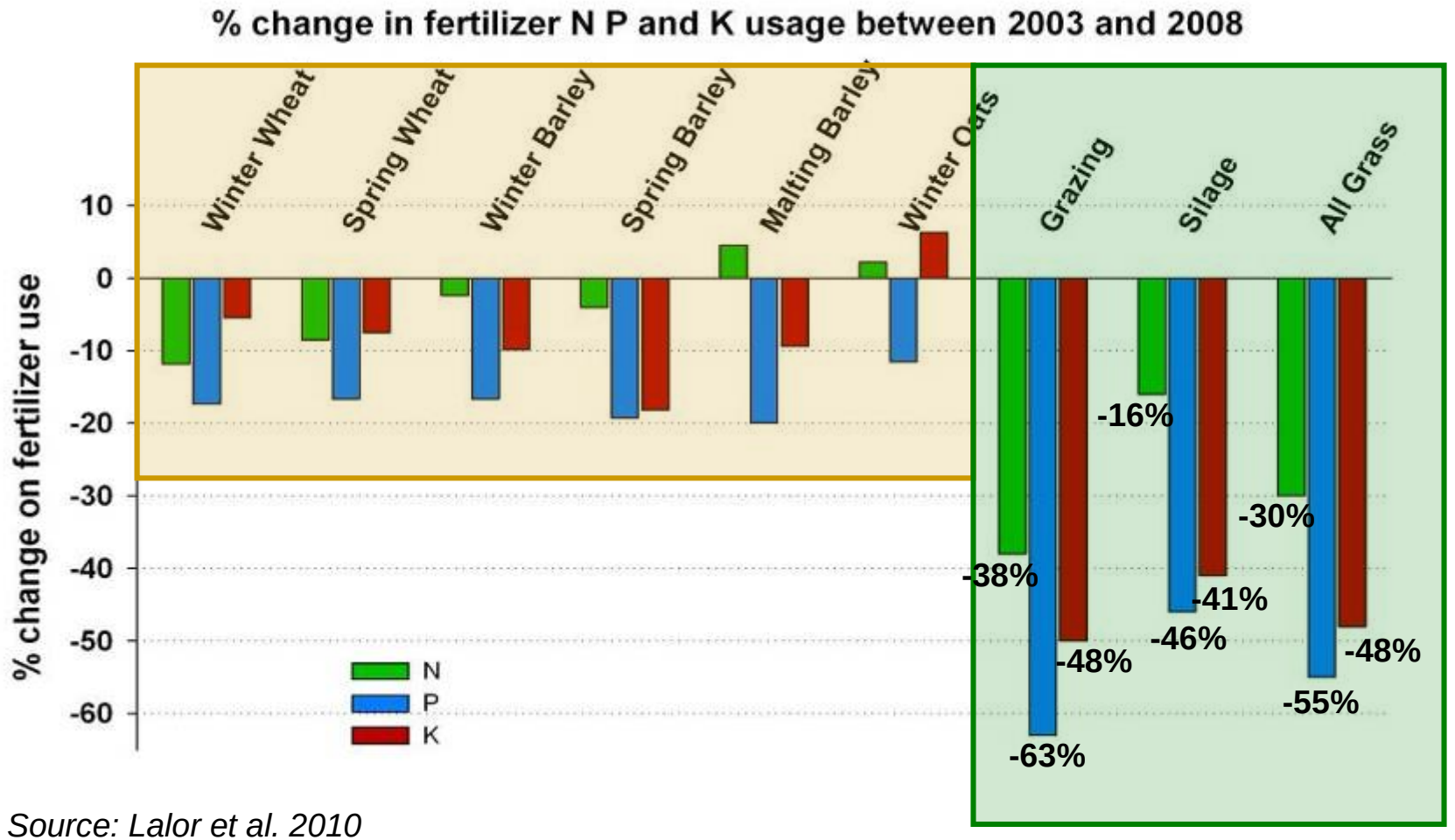
## Catchment-based Experimental Design

The NAP measures are about managing the nutrient SOURCE and MOBILISATION

The Surface and Groundwater/Drinking Water Regulations for monitoring the DELIVERY and IMPACT

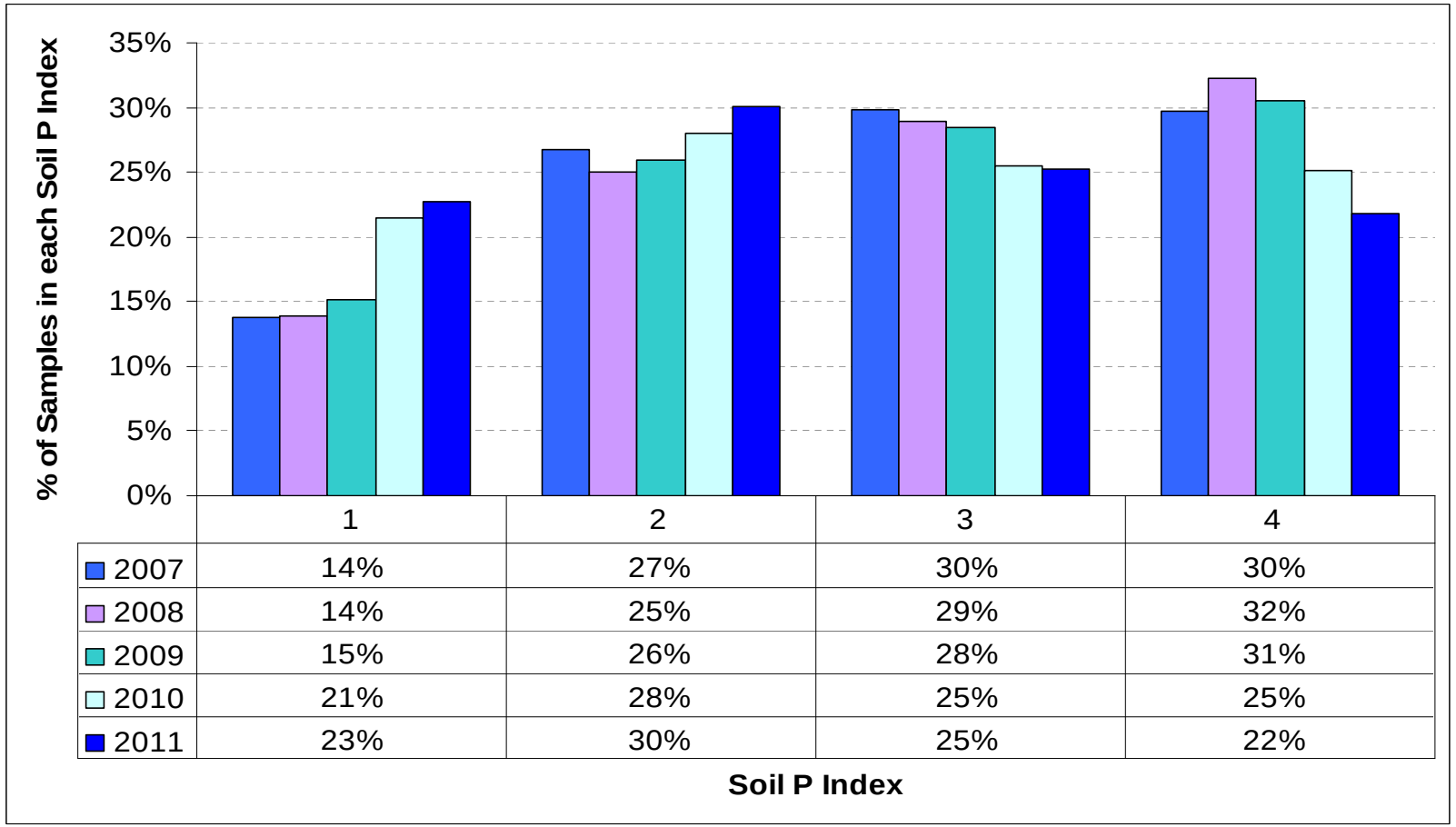
Wall et al. ES&P 2011

# National Fertilizer Use Trends for N, P, K




*Source: Lalor et al. 2010*

# National Soil Fertility Trends – Phosphorus (2007-2011)

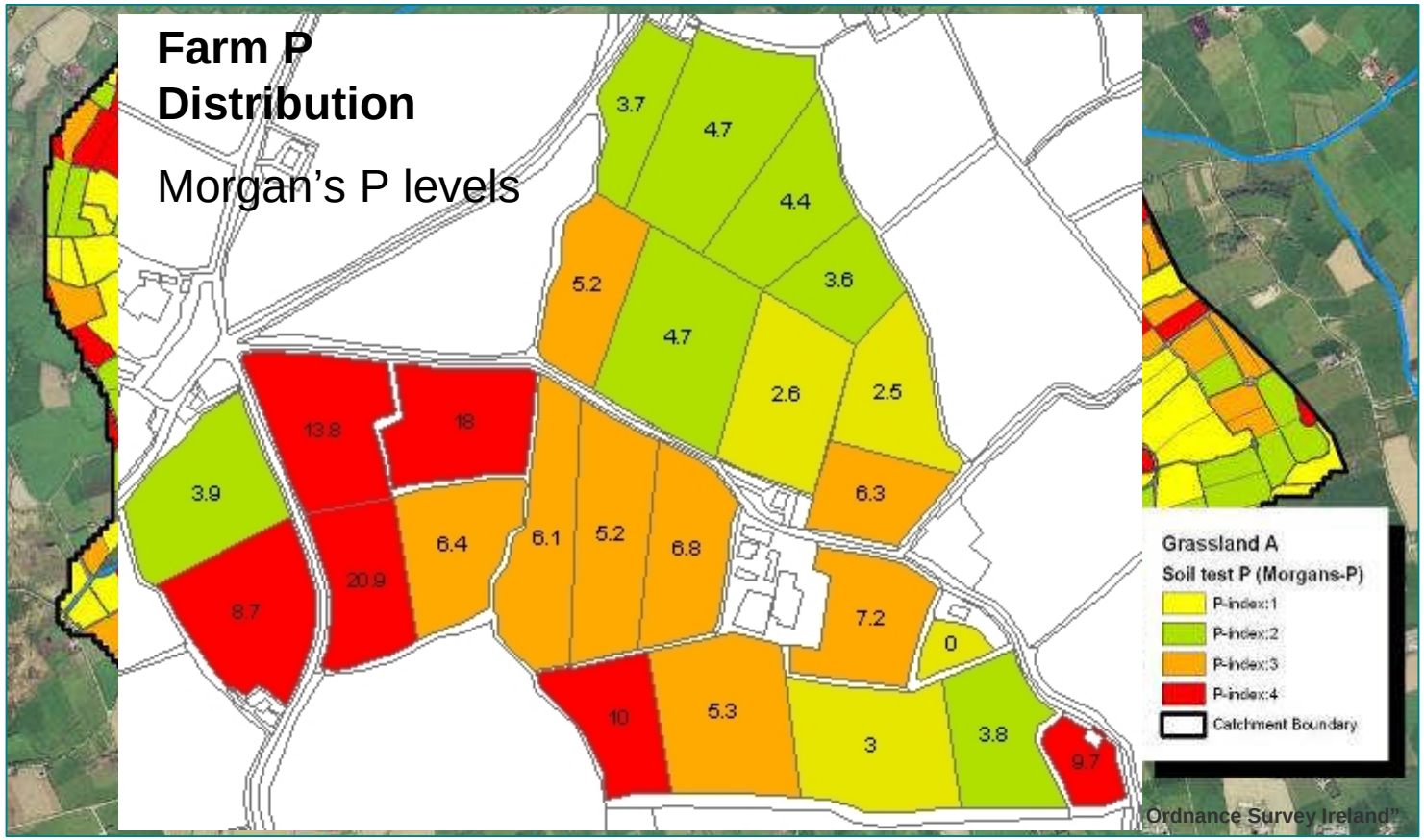



| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 2007 | 14% | 27% | 30% | 30% |
| 2008 | 14% | 25% | 29% | 32% |
| 2009 | 15% | 26% | 28% | 31% |
| 2010 | 21% | 28% | 25% | 25% |
| 2011 | 23% | 30% | 25% | 22% |

*Source: Teagasc*

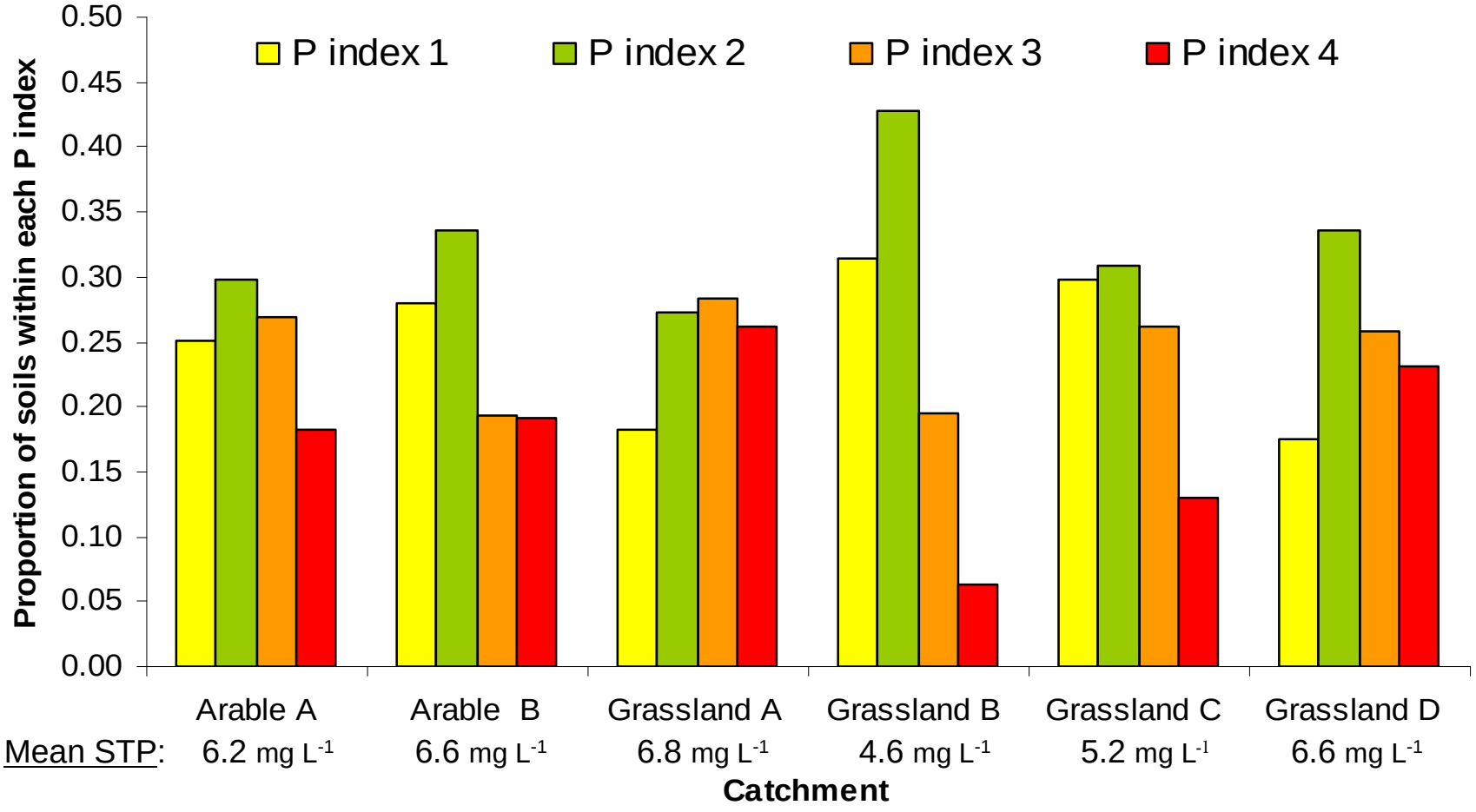
## Field-by-field (2ha) soil test

- Soil testing for P only required on derogation holdings
- Assume P index 3 (replacement) on non-derogation holdings



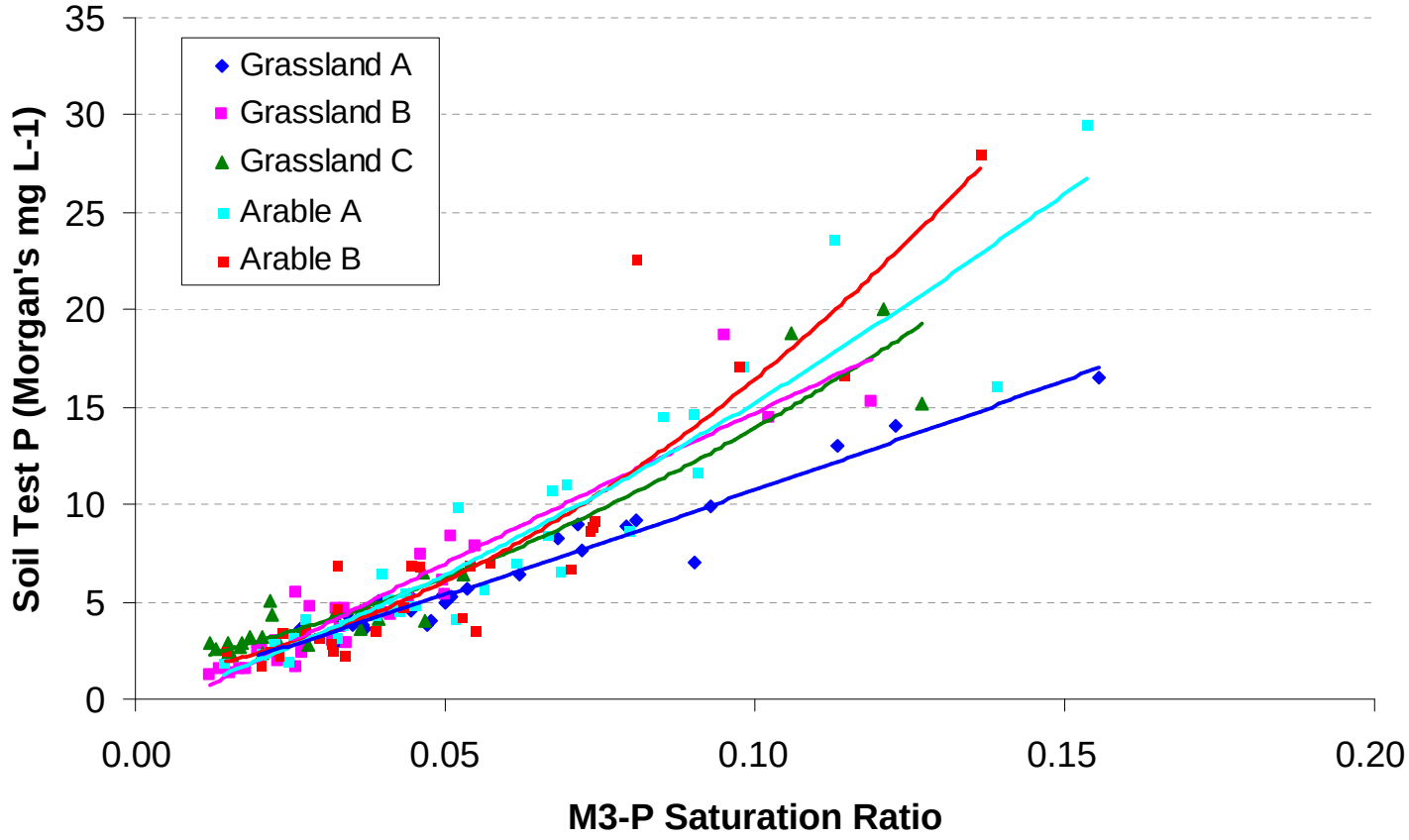
## Catchment soil P distribution

- Time-taken (lag) to return soil test P-index 4 soils to P-index 3?



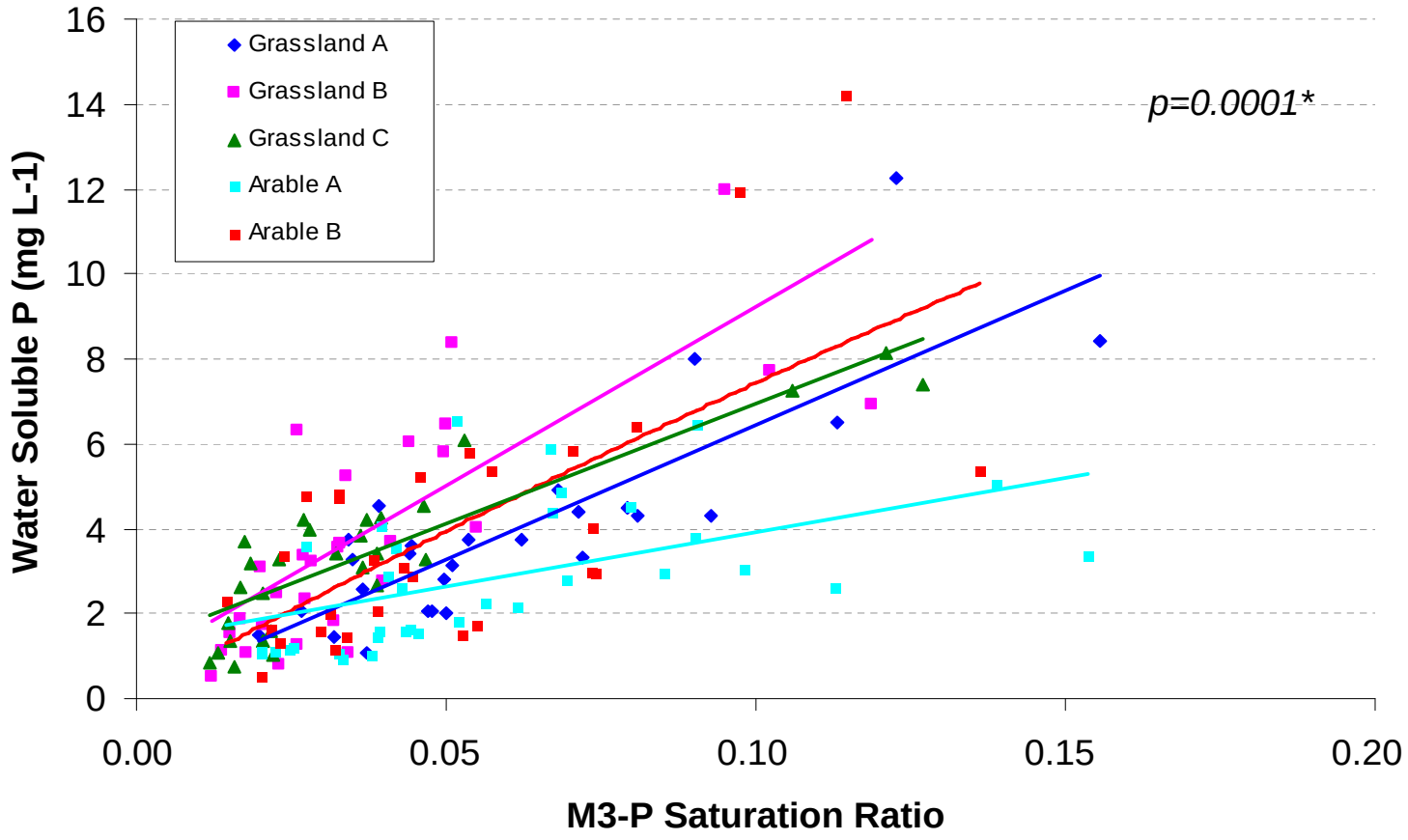

## Soil P saturation and storage

- Higher propensity for P loss with higher levels of soil P saturation
- Variability in soil P storage exists between soil types

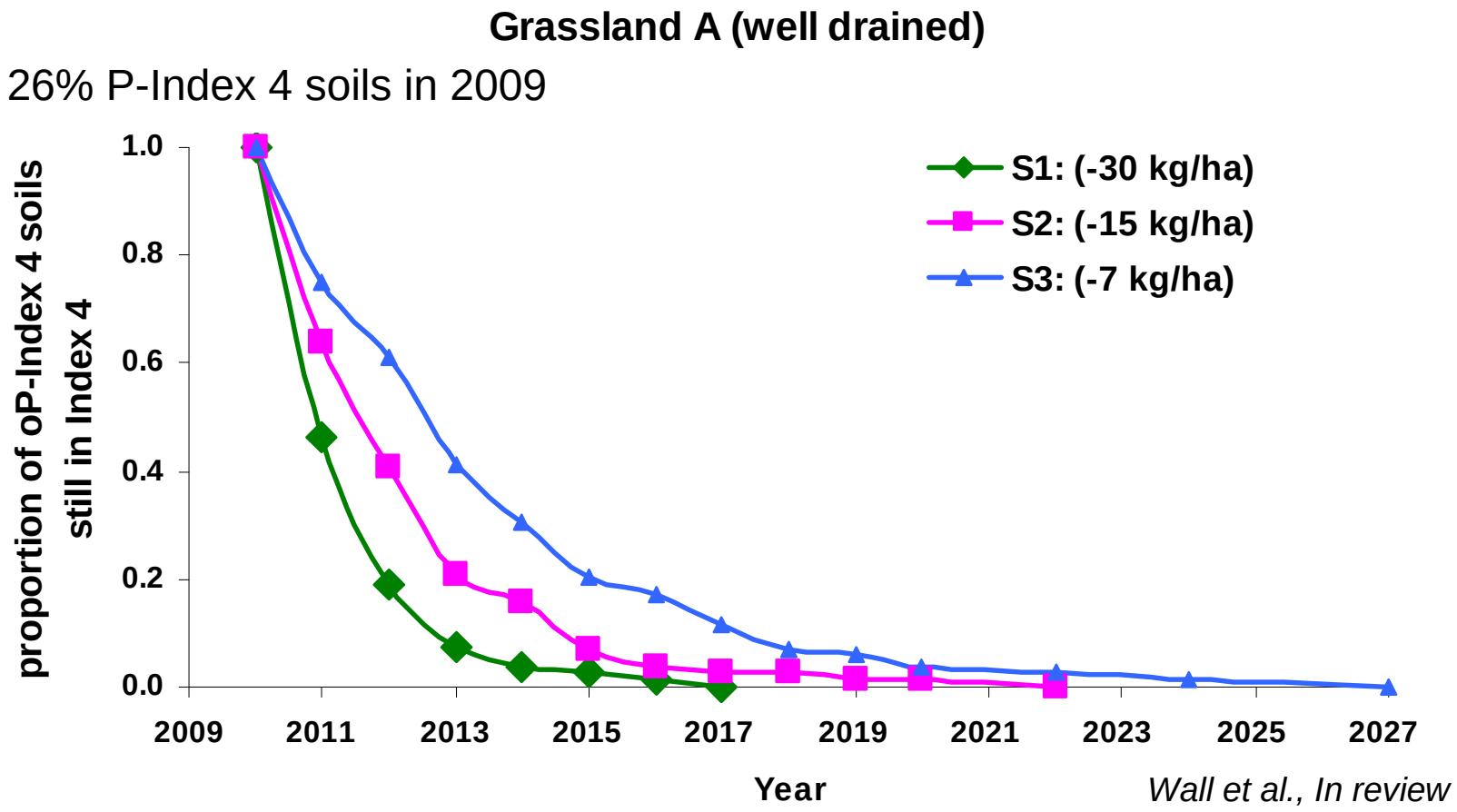


## Soil P mobilisation and loss risk

- Higher risk of P loss at higher levels of P saturation
- Variability in P loss (WSP) with different soil types?



# Lag- time in Soil P Decline for Restricted P Input Scenarios




*Wall et al., In review*

# Farm Gate N & P Balances

- Evaluating nutrient use efficiency on farms

| Catchment | Arable A | | Arable B | | Grassland A | | Grassland B | | Grassland C | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Farm* | *Farm 1* | | *Farm 2* | | *Farm 3* | | *Farm 4* | | *Farm 5* | |
| Farm Production Enterprise | Tillage & Lamb | | Beef & Tillage | | Dairy | | Dairy | | Beef and Lamb | |
| Farm Size | 60.6 ha | | 49.64 ha | | 59.58 ha | | 59.61 ha | | 56.00 ha | |
| Stocking Rate | 41 kg O.N. $ha^{-1}$ | | 67 kg O.N. $ha^{-1}$ | | 212 kg O.N. $ha^{-1}$ | | 142 kg O.N. $ha^{-1}$ | | 132 kg O.N. $ha^{-1}$ | |
| **Imports** | *N* | *P* | *N* | *P* | *N* | *P* | *N* | *P* | *N* | *P* |
| Fertilisers | 8200 | 1600 | 7828 | 431 | 11460 | 30 | 8527 | 1255 | 5164 | 200 |
| Bulky Feeds | 0 | 0 | 0 | 0 | 662 | 126 | 0 | 0 | 162 | 34 |
| Concentrate Feeds | 184 | 51 | 68 | 16 | 3053 | 843 | 698 | 193 | 587 | 128 |
| Cattle Purchases | - | - | 0 | 0 | 14 | 6 | 14 | 6 | 0 | 0 |
| Sheep Purchases | 33 | 11 | - | - | - | - | - | - | 0 | 0 |
| **Total** | **8417** | **1662** | **7896** | **447** | **15189** | **1005** | **9239** | **1454** | **5913** | **362** |
| **Exports** | *N* | *P* | *N* | *P* | *N* | *P* | *N* | *P* | *N* | *P* |
| Cattle Sales | 120 | 41 | 425 | 177 | 202 | 80 | 201 | 79 | 669 | 281 |
| Sheep Sales + Wool | 7 | 2 | - | - | - | - | - | - | 339 | 117 |
| Dead Animals | 2 | 1 | 2 | 1 | 141 | 56 | 14 | 5 | 7 | 3 |
| Milk Sales | - | - | - | - | 4285 | 756 | 2050 | 386 | - | - |
| Crop Sales | 8350 | 1513 | 4870 | 925 | - | - | - | - | - | - |
| **Total** | **8479** | **1557** | **5297** | **1103** | **4628** | **892** | **2265** | **470** | 1015 | 401 |
| **WholeFarmBalance** = (Imports - Exports) | **-62** | **105** | **2599** | **-625** | **10561** | **113** | **6974** | **984** | **4898** | **-37** |
| **N Surplus (kg/ha)** | **+1.0** | | **+52.3** | | **+177** | | **+117** | | **+87** | |
| **P Surplus (kg/ha)** | | **+1.7** | | **-12.6** | | **+1.9** | | **+16.5** | | **-0.7** |
| **Soil P Required** (STP ≤Index 3) | **60%** | **799** | **14%** | **291** | **4%** | **383** | **90%** | **1730** | **66%** | **1215** |

# Nitrogen Fertiliser Input to Catchment Fields

| Crop | | Arable A | Arable B | Grassland A | Grassland B | Grassland C |
|---|---|---|---|---|---|---|
| Mean kg Org. N $ha^{-1}$ * | | 64 | 96 | 155 | 102 | 110 |
| | *n Fields* | *30* | *215* | *215* | *124* | *359* |
| | Max | 137 | 334 | 421 | 467 | 231 |
| Grassland | Mean | 67 | 114 | 226 | 128 | 46 |
| Crop requirement$^{\Delta}$ | | 40-75 | 75-110 | 150-185 | 75-110 | 75-110 |
| Main | Max | 190 | 226 | 236 | 160 | - |
| Crop | Mean | 129† | 158‡ | 163# | 135† | - |
| Crop requirement$^{\Phi}$ | | 135 | 210 | 180 | 135 | |

† Spring Barley, ‡ Winter Wheat, # Maize for Silage

Δ, Grass N requirement is N needed for grass production for the mean stocking rate for the catchment

Φ, Crop N requirement is N needed for crop production based on the type of crop production on N index 1 soils

# Phosphorus Fertiliser Input to Catchment Fields

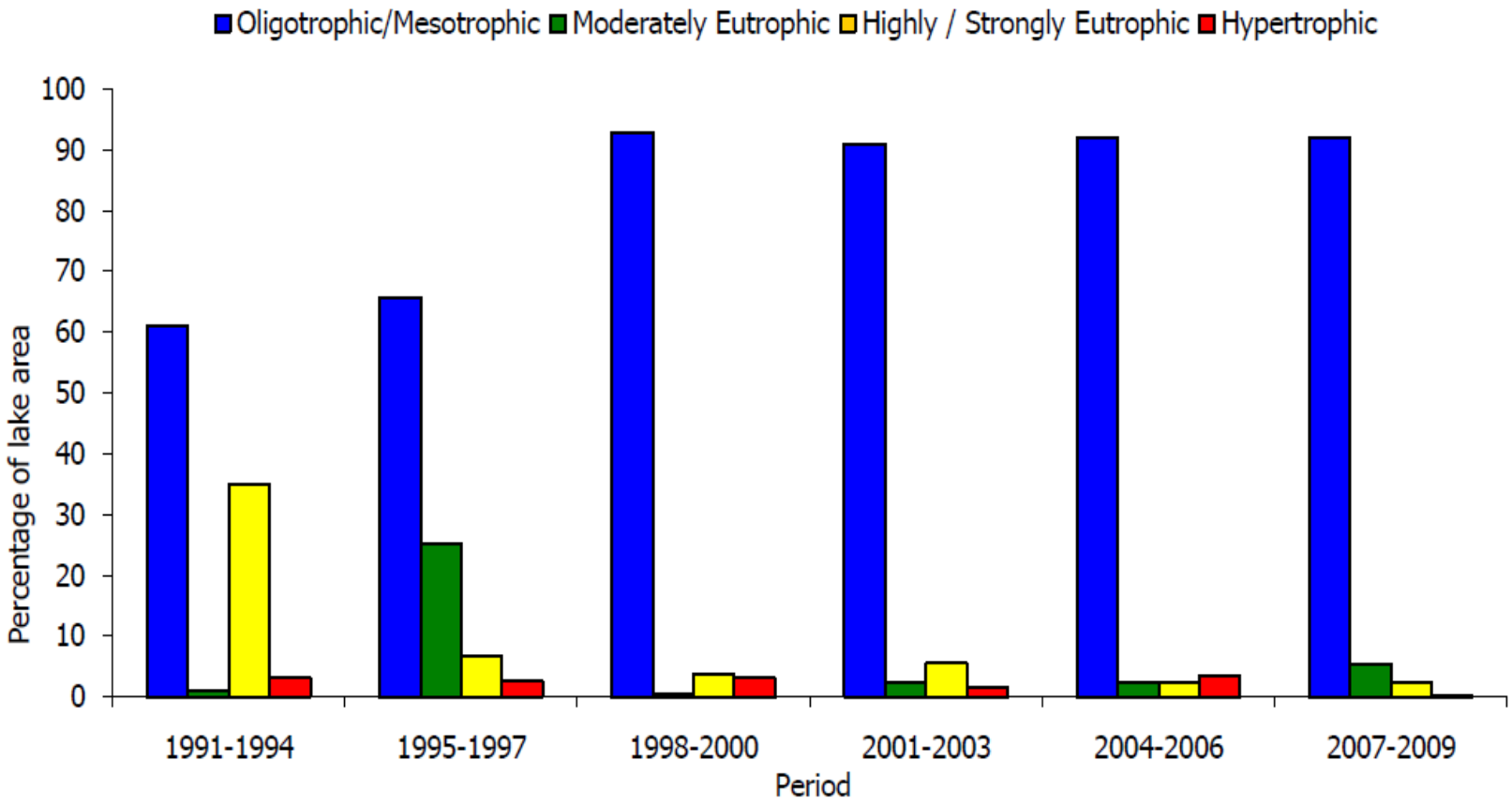
| Crop | | Arable A | Arable B | Grassland A | Grassland B | Grassland C |
|---|---|---|---|---|---|---|
| Mean kg Org. P $ha^{-1}$ * | | 8 | 14 | 23 | 15 | 16 |
| | *n Fields* | *30* | *215* | *215* | *124* | *359* |
| | Max | 37 | 50 | 36 | 55 | 37 |
| Grassland | Mean | 9 | 5 | 4 | 9 | 4 |
| **Grass requirement$^{\Delta}$** | | **4** | **5** | **9** | **7** | **5** |
| Main | Max | 68 | 37 | 41 | 37 | - |
| Crop | Mean | 25† | 7‡ | 7# | 23† | - |
| **Crop requirement$^{\Phi}$** | | **29** | **42** | **40** | **29** | |

† Spring Barley, ‡ Winter Wheat, # Maize for Silage

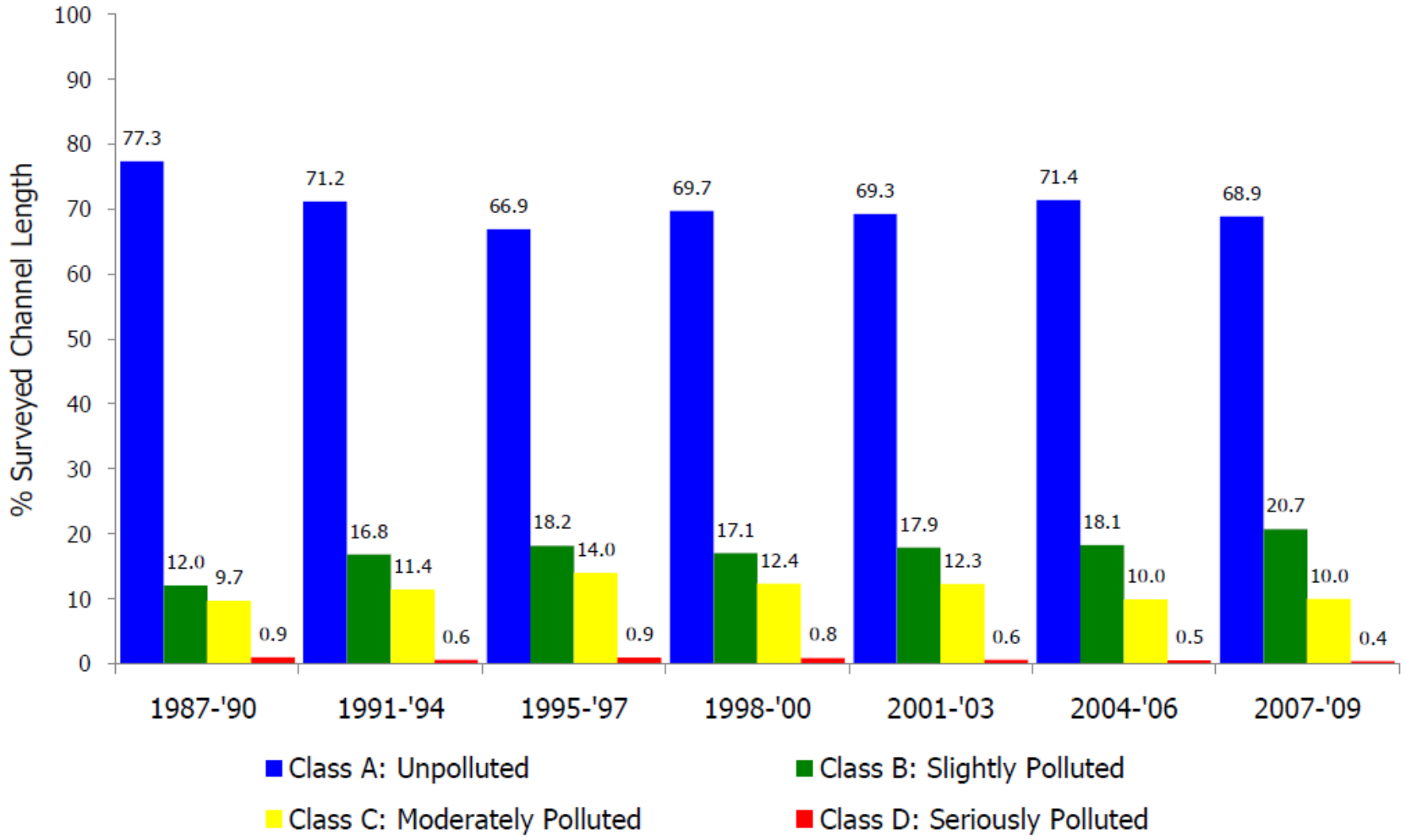
Δ, Grass P requirement is P offtake based on the type of animal production and mean stocking rate for catchment

Φ, Crop P requirement is crop P offtake based on the type of crop production, assuming average yields

# Irish Lake Water Quality up to 2009



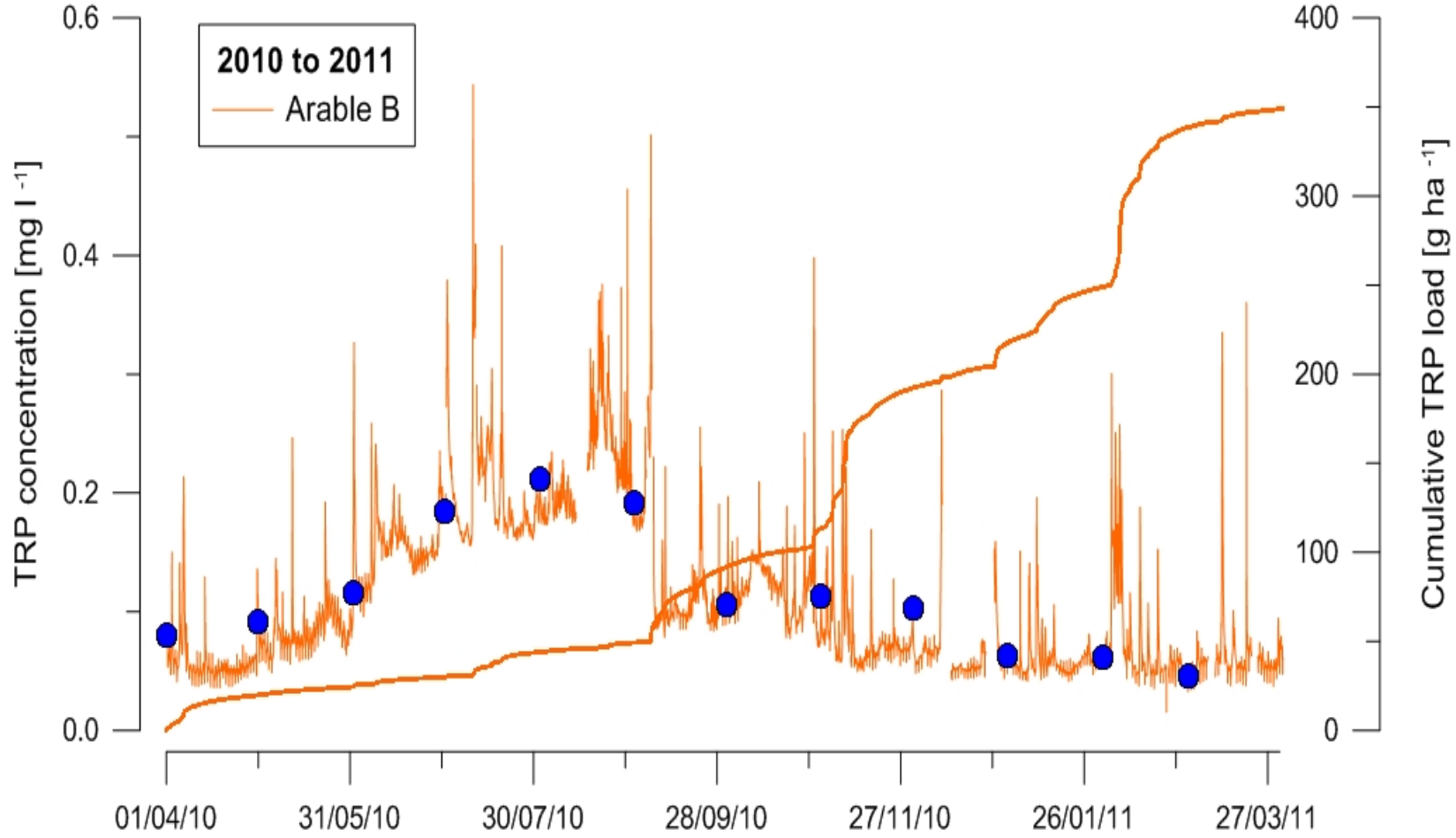
# Irish River Water Quality up to 2009



**Outlet sub-hourly measurements**

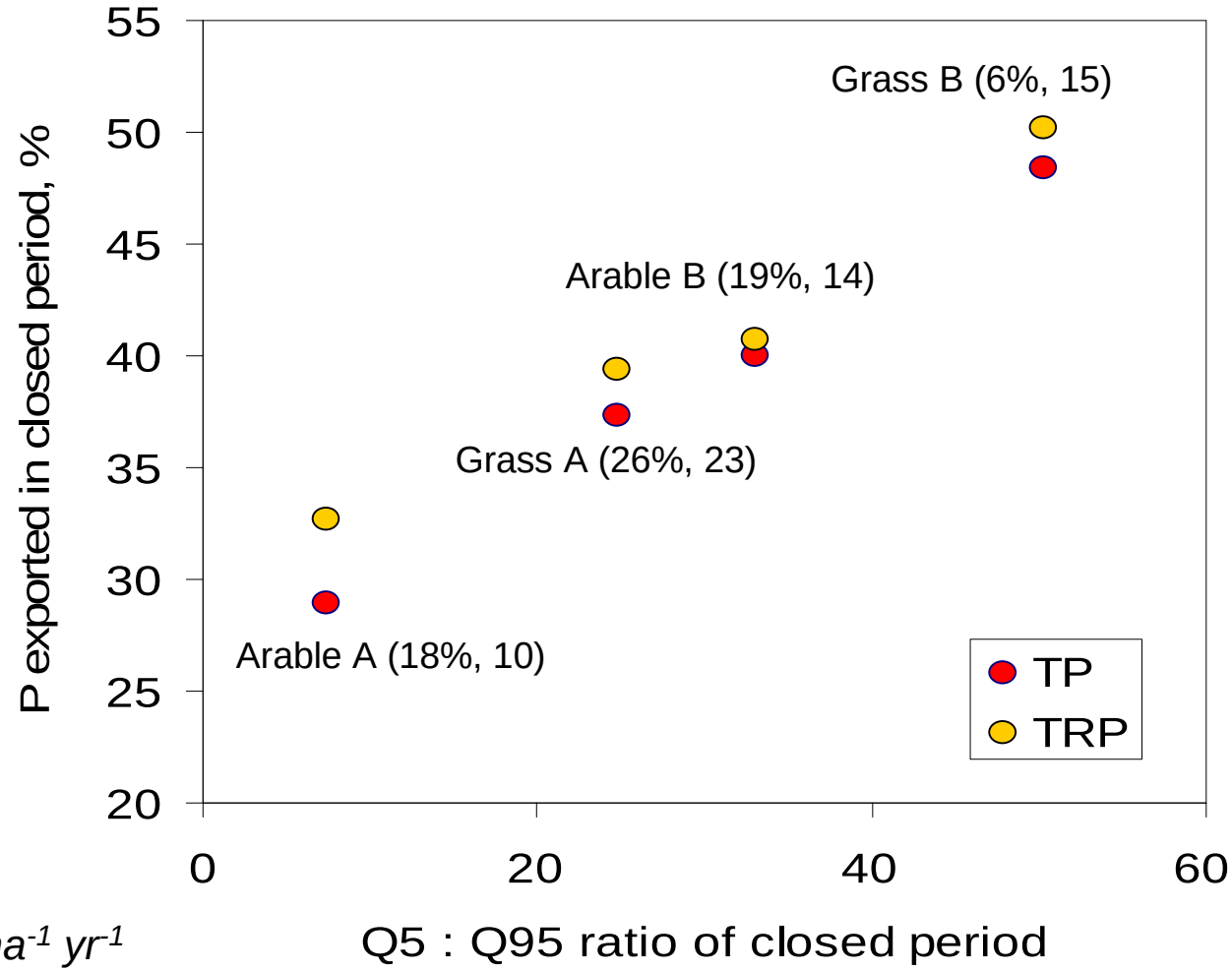
- Discharge
- TP
- TRP
- TON
- Temperature
- Conductivity
- Turbidity

# High resolution water quality monitoring vs. 12 monthly samples



# Catchment runoff flashiness & P export during “closed period”

2010-2011




*In brackets:*
*% soil P index 4*
*Mean organic P kg ha$^{-1}$ yr$^{-1}$*

## Conclusions

- There is a policy expectation that BMP at farm scale will cascade down and be neutral or beneficial to water quality at catchment scale.
- Policy (mitigation measures) and Expectations (water Q targets) may not always be linked.
- Many DISCONNECTIONS may exist which are masked by monitoring scales.
- Legacy effects exist - change may not be fast!
- Source complexity & lag times increase with catchment scale.
- Effective scientific evaluation must be adaptive, inclusive and work at multiple scales when and where appropriate

## Implications for the evaluation of environmental policy

- Implementation of mitigation measures must be complimented with monitoring at appropriate scales to evaluate their efficacy
- Long term monitoring may be required at multiple scales to disentangle CAUSE and EFFECT
- Time scales from implementation to targets must be realistic
- Goals must be realistic and achievable
  - spatial and temporal variability
  - biophysical and socio-economical variability
- Integrated catchment studies provide a realistic scale for evaluation
  - N and P transfer impacts may be buffered
  - Facilitates science-farmer partnerships
  - Mimic large scale dynamics but also allows process level studies

AGRICULTURAL CATCHMENTS PROGRAMME

***The Agricultural Catchments Programme:***
***An environmental and socio-economic evaluation of the Nitrates Directive National Action Programme in Ireland***

***www.teagasc.ie/agcatchments***

Acknowledgements:

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- Catchment farmers for their participation in the programme
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