

# **Refining nutrient management for extensively managed grassland**

**Suzanne Higgins, Gillian Nicholl, Russell Adams, Emma Hayes, Sara Vero & Donnacha Doody**





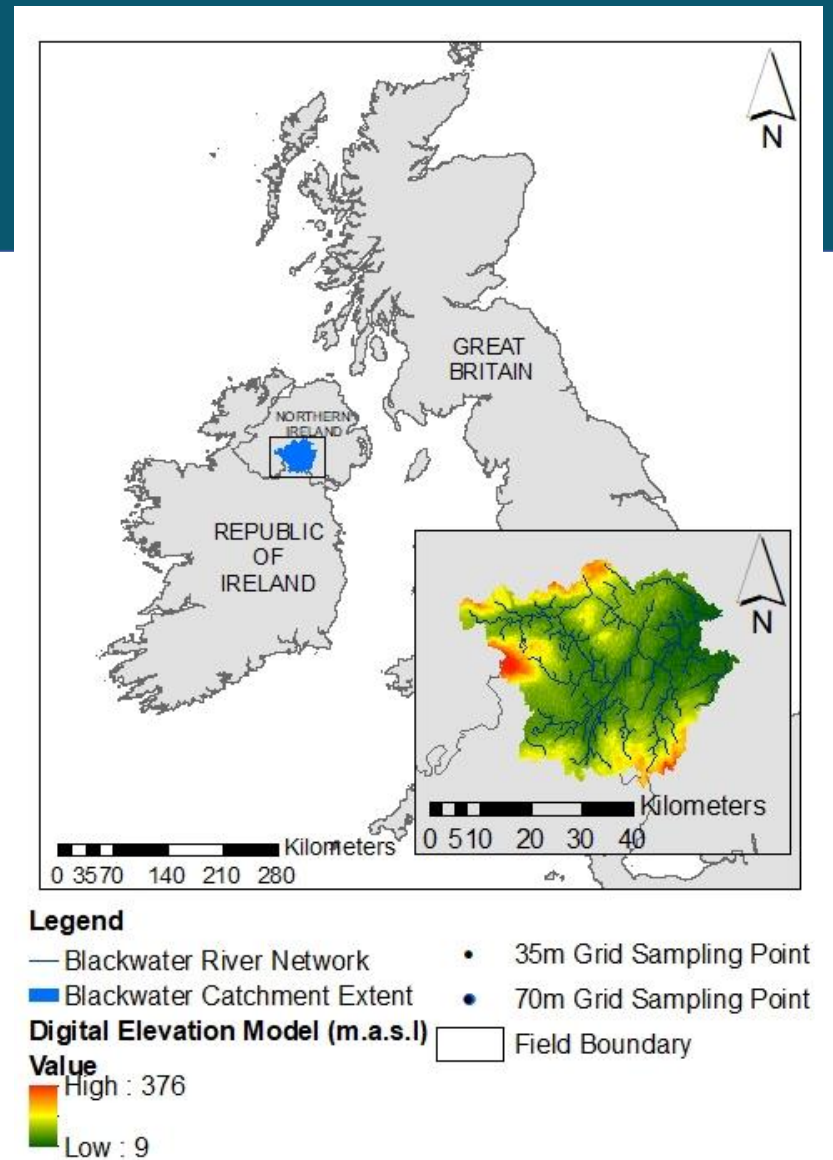
- Seven research centres across NI
- Research Farm at AFBI Hillsborough
- Marine research vessel
- Agriculture, food, marine, veterinary sciences, plant sciences
- Agri Environment

- Background: Water quality in NI and cross border water bodies
- Introduction to extensively managed grassland
- Loss of phosphorus from grassland soils
- CatchmentCARE project: New fertiliser guidelines for extensively managed systems
- Increasing the precision of farm nutrient management

# Water Quality in Northern Ireland & Cross-Border Water Bodies

- In NI the Water Framework Directive (WFD) is implemented through River Basin Management Plans.
- NI shares three International River Basin Districts with RoI
- In this presentation I will focus on the Blackwater Catchment (Neagh-Bann IRBD)
- Tyrone, Armagh & Monaghan

Hayes et al. 2021





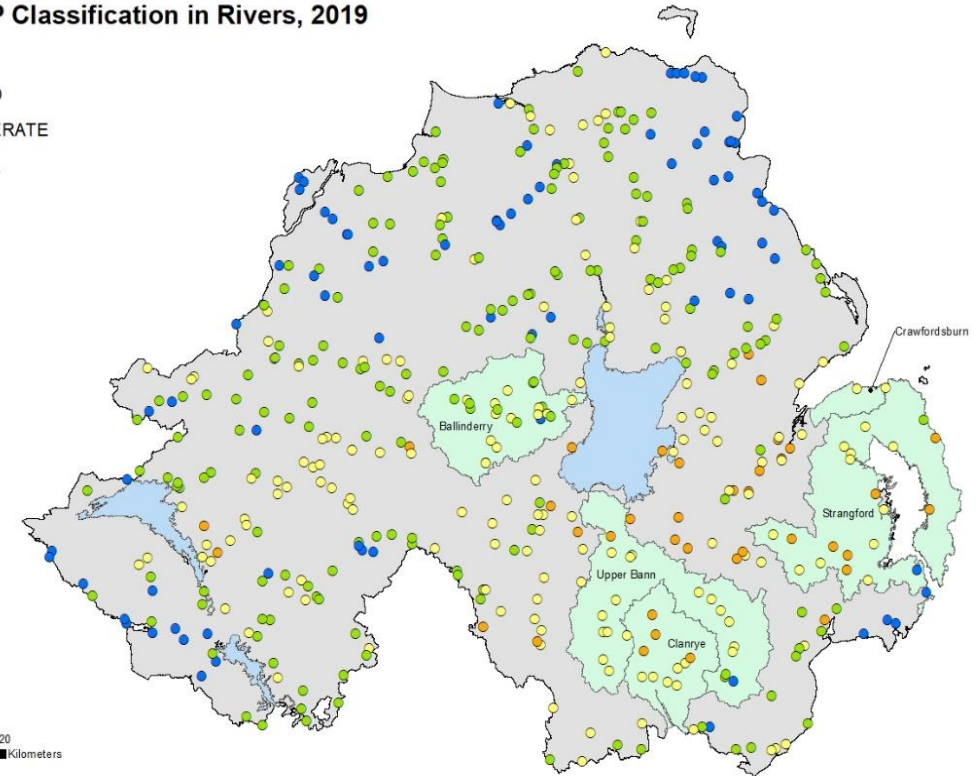
# Water Quality in Northern Ireland & Cross-Border Water Bodies



- Water bodies (rivers, lakes & groundwater) are monitored continuously for chemical and ecological status and this data reported to the Commission
- In recent years there has been a slight deterioration in water quality
- 2019: 44% of river sites had SRP classification of moderate or poor
- 2012 – 2015: 34%
- Nearly a third of sites have deteriorated by one class for WFD SRP status

WFD SRP Classification in Rivers, 2019

- HIGH
- GOOD
- MODERATE
- POOR
- BAD

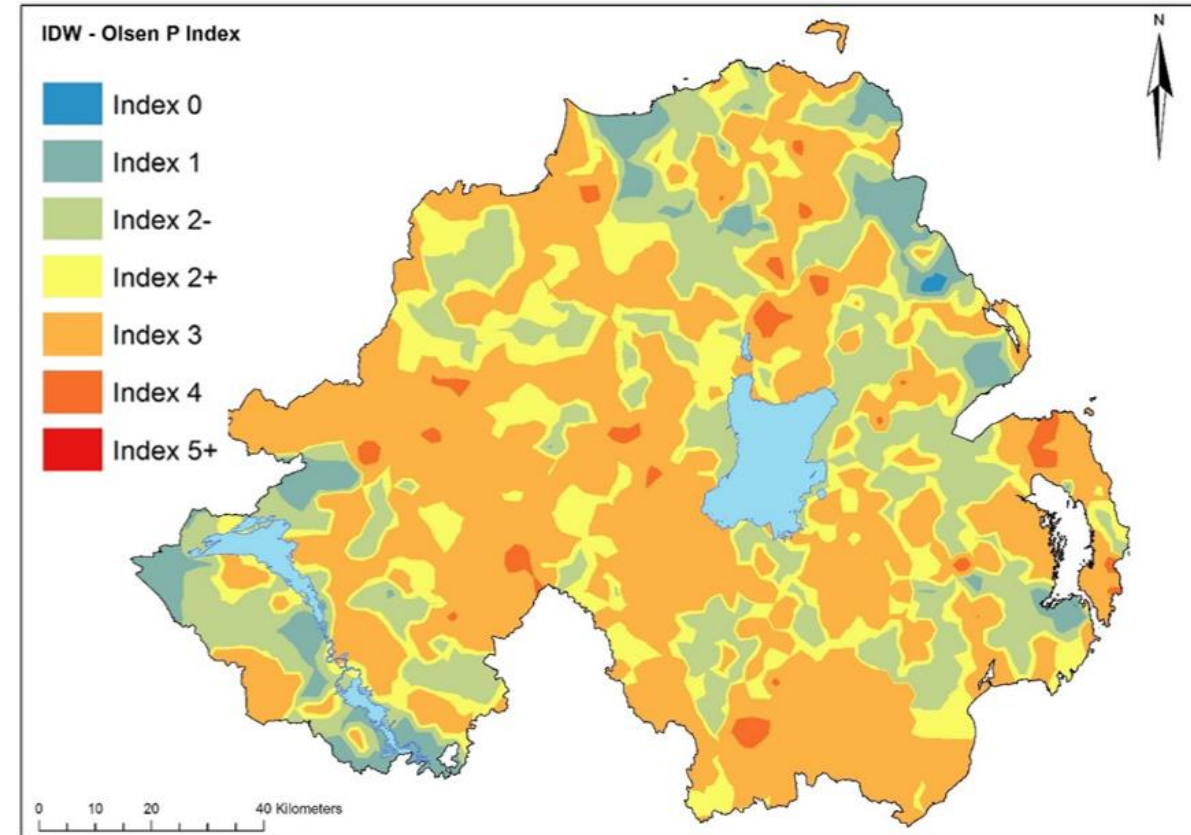


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# Farm and field management of phosphorus inputs

- Agricultural land acts as a point and diffuse source of phosphorus (P) loss into waterways
- Recent soil sampling schemes such as the EAA scheme showed that 50% of soils in NI contain high or surplus levels of soil P
- Soil P above what is required for agronomic production
- Increased risk of P loss. 940 tonnes of agricultural P are lost to water bodies each year





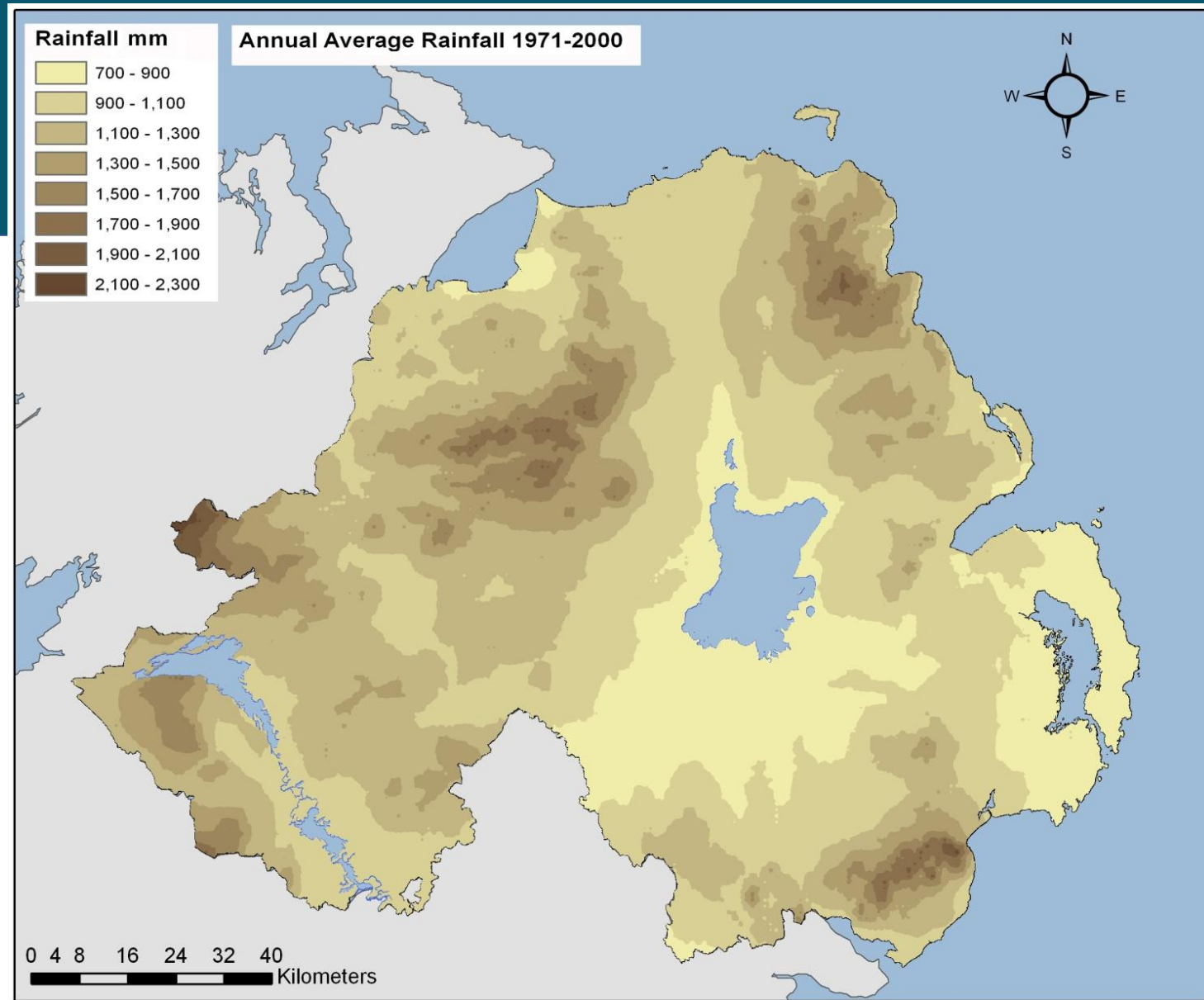
# High Soil Phosphorus

- Historically there has been a tendency to over-apply P (above what is required for production)
- High slurry and chemical P applications
- The risk of nutrient loss from agricultural land is greater in certain conditions
- To reduce the risk of nutrient loss, environmental regulations have been enforced (Nutrients Action Programme)
- Closed period 39% reduction in SRP loss



# Climate

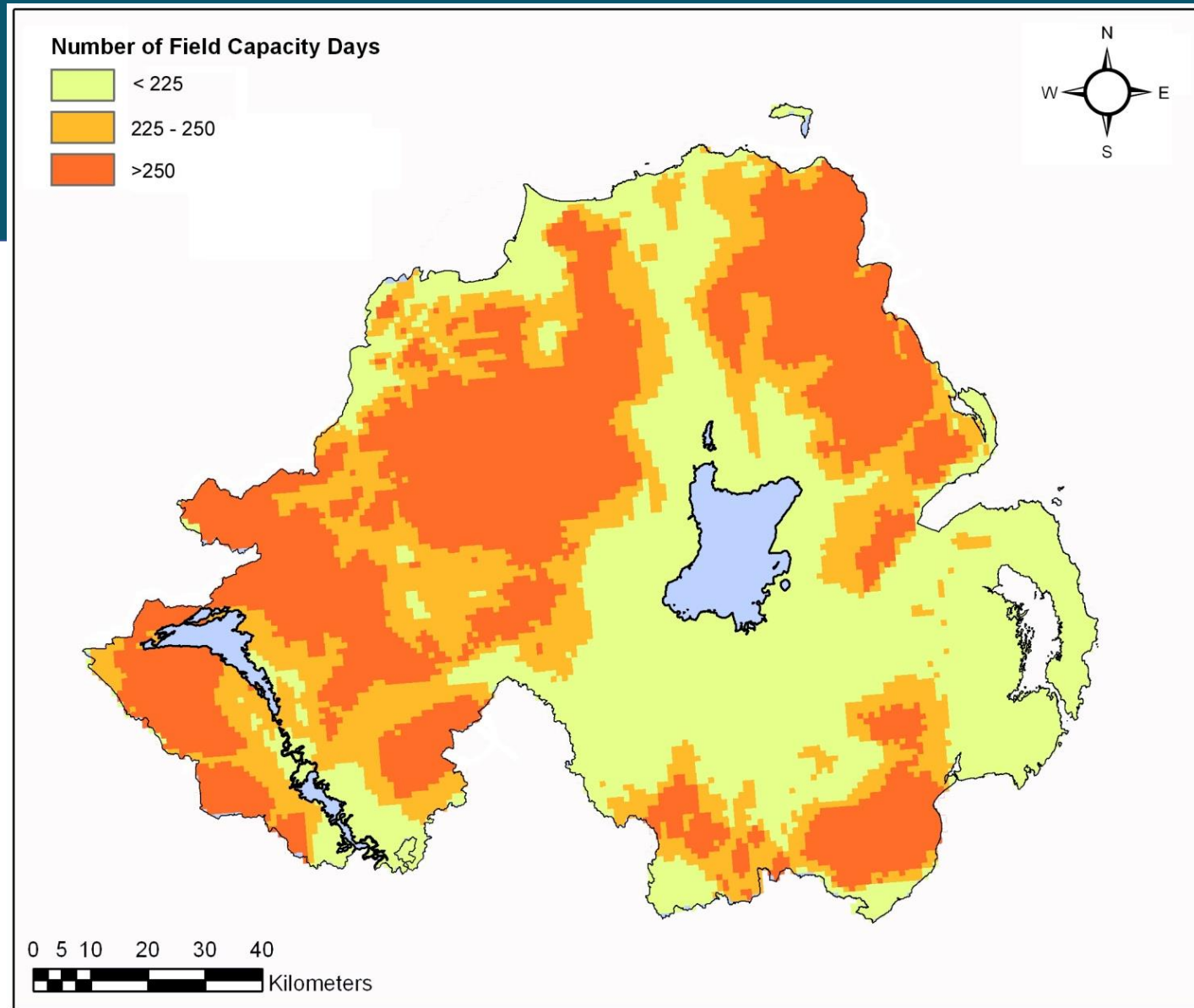
- High rainfall climate  
1000 – 2000 mm rainfall  
annually





# Saturated Soils

- Soils can be saturated or above field capacity for > 250 days per year

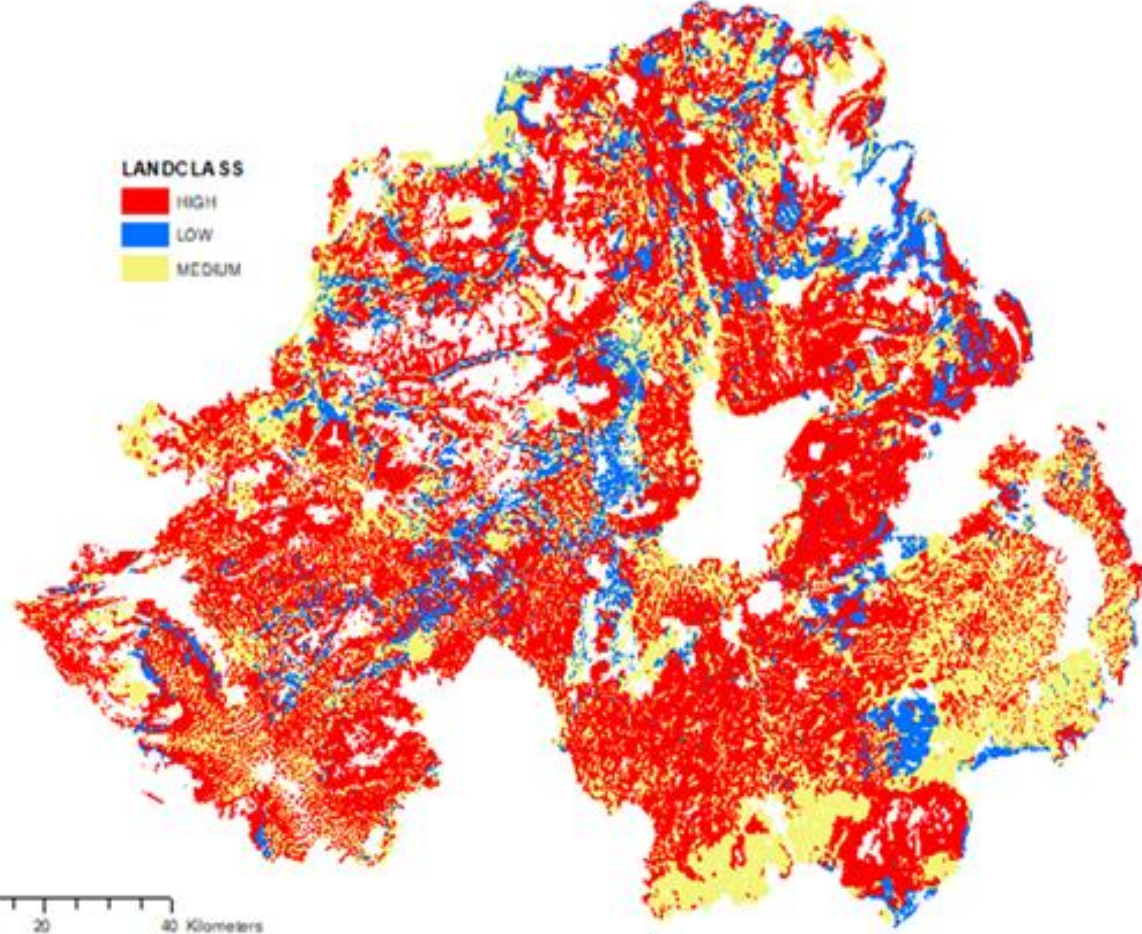


# Runoff Risk - Spatial Variability

*Based on the UK Hydrology of Soil Type Classification*



<i>High Runoff Potential</i>	58%
<i>Medium Runoff Potential</i>	31%
<i>Low Runoff Potential</i>	11%



D. Doody,  
R. Cassidy,  
R. Adams,  
A. Higgins







# Diffuse and point source pollution





# CatchmentCARE

- CatchmentCARE is an EU-funded project that aims to improve freshwater quality within the North Western and Neagh Bann international river basins.
- The project is focussed across three cross-border catchments, the Arney, Blackwater and Finn



Blackwater catchment 1,500 km<sup>2</sup>: Neagh-Bann IRBD

Finn catchment 494 km<sup>2</sup>: North Western IRBD

Arney catchment 304 km<sup>2</sup>: North Western IRBD

# CatchmentCARE

- **Aims:** Development of a number of water quality improvement projects and installation of groundwater monitoring stations across the region
- **Project Partners:**
  - Donegal County Council (Lead)
  - AFBI
  - Inland Fisheries Ireland
  - Loughs Agency
  - Ulster University
  - Armagh City, Banbridge & Craigavon Borough Councils
  - British Geological Survey
  - Geological Survey Ireland



# CatchmentCARE

- Project funded under the EU Interreg VA Programme
- Budget €13,792,432
- Match funding of €2,068,865.37 provided by Government departments
- **Project Actions:**
  - A measurable impact on water quality
  - Be transferable beyond the three catchments
  - Contribute to a project legacy

# Aims of Catchment CARE

- Identifying strategies to manage phosphorus inputs at farm scale and individual field level
- Reduction in number of fields over-supplied with P
- Develop an evidence base that will help shape future regulations in relation to soil nutrient management
- Development of recommendations that are appropriate for cross border farms



# Re-evaluating current fertiliser recommendations

- Current fertiliser recommendations favour high-production systems
- Grassland receiving high N inputs (fertiliser + manure over 300 kg N/ha/yr)
- High target yields 12 – 16 t DM/ha/yr in 3 silage cuts
- However, much of NI and RoI agriculture is not operating at this intensity
- Extensively managed livestock farms in NI generally have total fertiliser inputs less than 60 kg N/ha/yr and manure less than 120 kg N/ha/yr
- Expected yields 4 – 7 t DM/ha/yr through 1-2 silage cuts per year

# Extensively managed grasslands

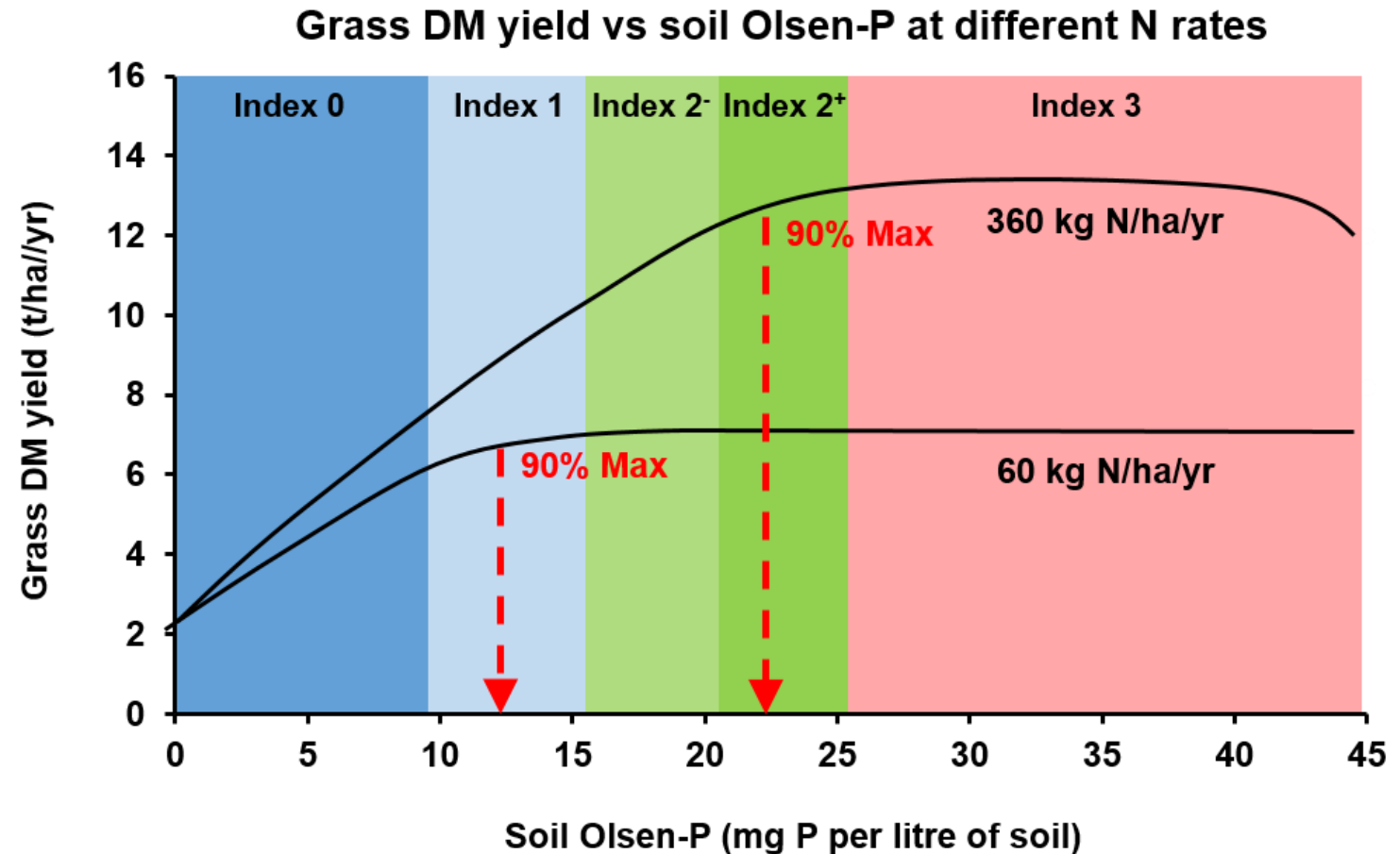
- A landscape which comprises a large proportion of the land area of NI and RoI
- Currently minimal published data assessing the P requirements of low-input extensive grassland
- Over-application of P to extensive systems could be making a significant contribution to P inputs into waterways





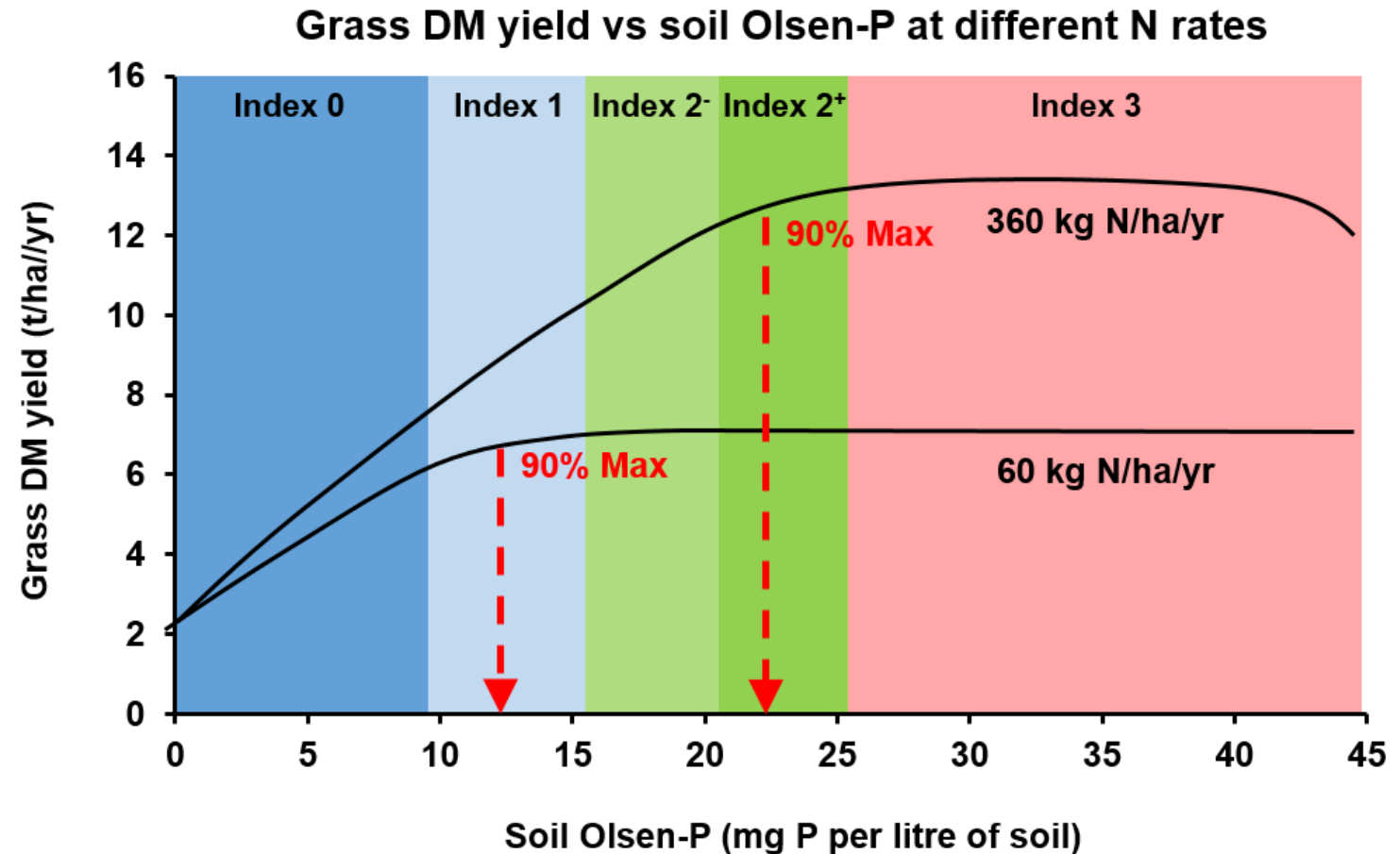
# Liebig's Law of the Minimum

- Max yield determined by the most limiting nutrient
- In extensive systems the low N rate is generally the limiting factor
- Due to the low N input, max attainable yield may be 7 t DM/ha/yr
- Even if more P is applied, yield will not increase as the system is limited by N supply



# Liebig's Law of the Minimum

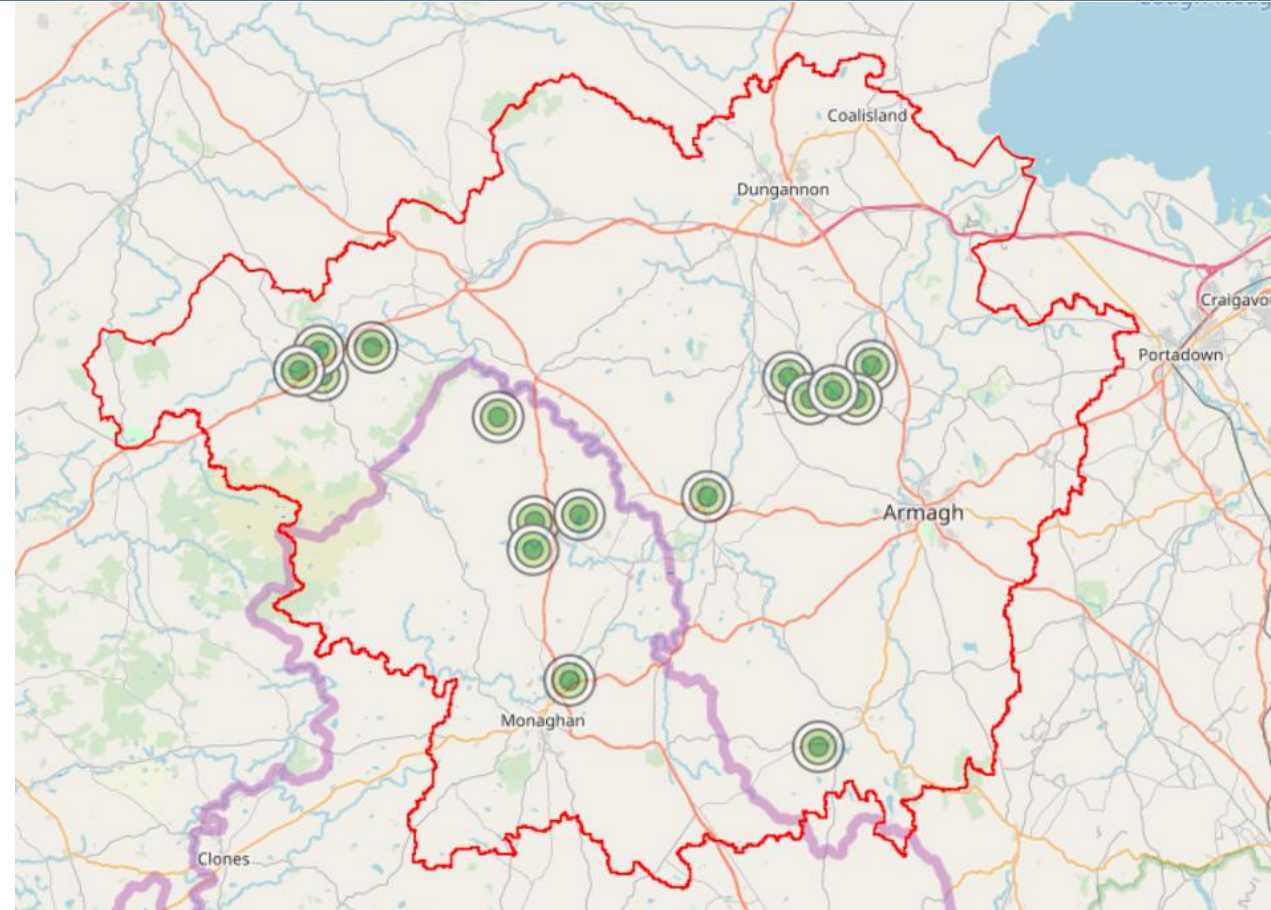
- Where N input is low, P uptake and P requirement will be lower
- On an input of 60 kg N/ha/yr, an Olsen P Index of 1 may be sufficient
- For a higher N input system, 90% of max yield correlated with Index 2+





# Tackling Legacy Soil P in Catchment CARE

- High levels of legacy soil P, especially where more P is applied than required for production
- Catchment CARE aims to refine the nutrient advice given to farmers
- Farm specific advice based on farm activity level
- 17 farms selected in the Blackwater cross-border catchment



# Blackwater Catchment

- Blackwater catchment 1,500 km<sup>2</sup>: Neagh-Bann International River Basin District
- Tyrone, Armagh & Monaghan
- 90% of land use as agriculture (diary, beef & sheep)
- Geology: Carboniferous sandstone, limestone, shale and mudstone overlaid by pro-glacial boulder till
- Soils: poorly draining with a seasonally perched water table promoting saturation-excess runoff
- High winter rainfall, high runoff risk, low water storage capacity and poor permeability: factors which elevate the diffuse pollution risk



# Nutrient Management Component of CC

- Two main parts:
- 1. Mapping soil P content of all fields on 17 farms. Preparing nutrient management plans for farmers
- 2. Evaluating P recommendations for extensively managed grasslands within the revised Nitrates Action Programme (NAP)

# Soil Sampling of 17 farms (Jan – Mar 2019)



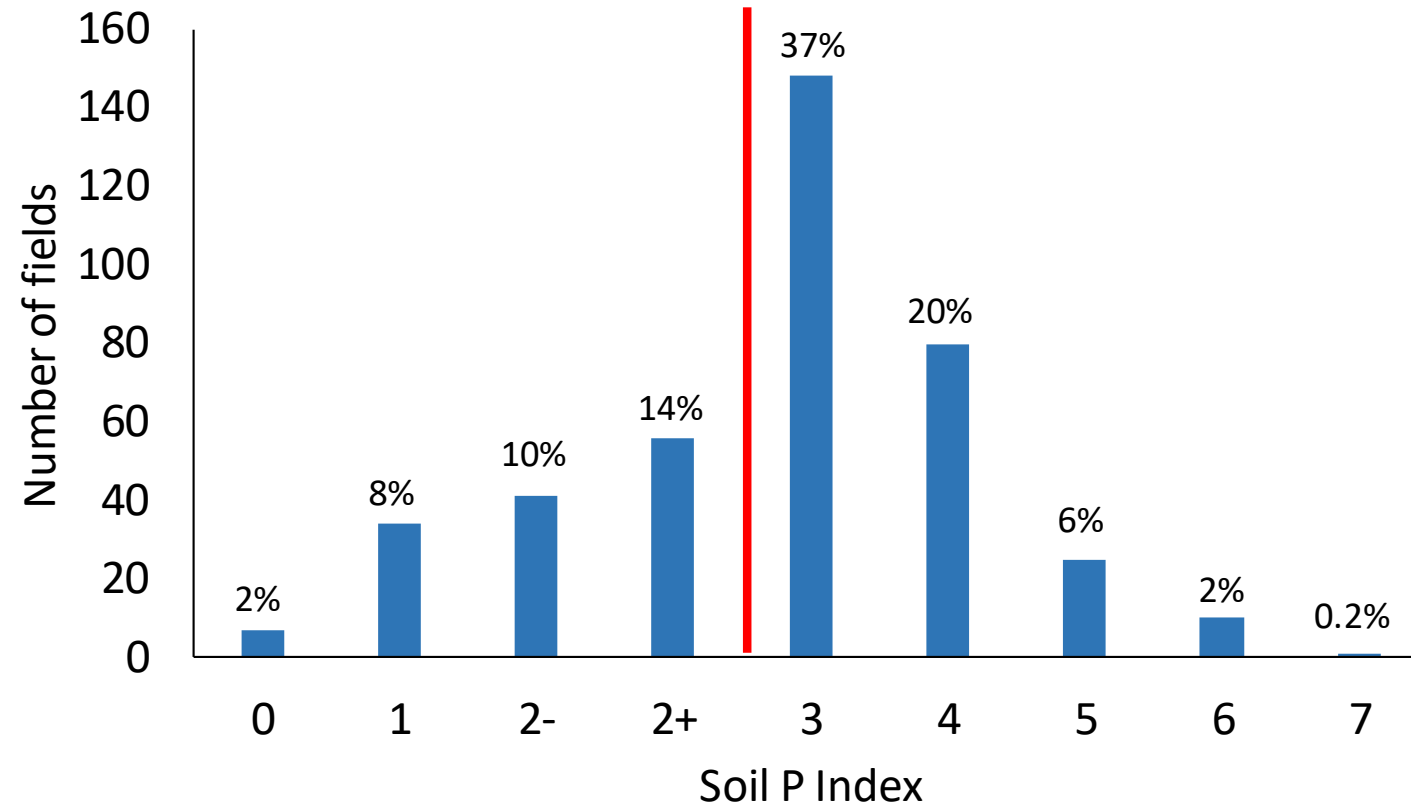
400 fields sampled



# Soil Sampling of 400 fields

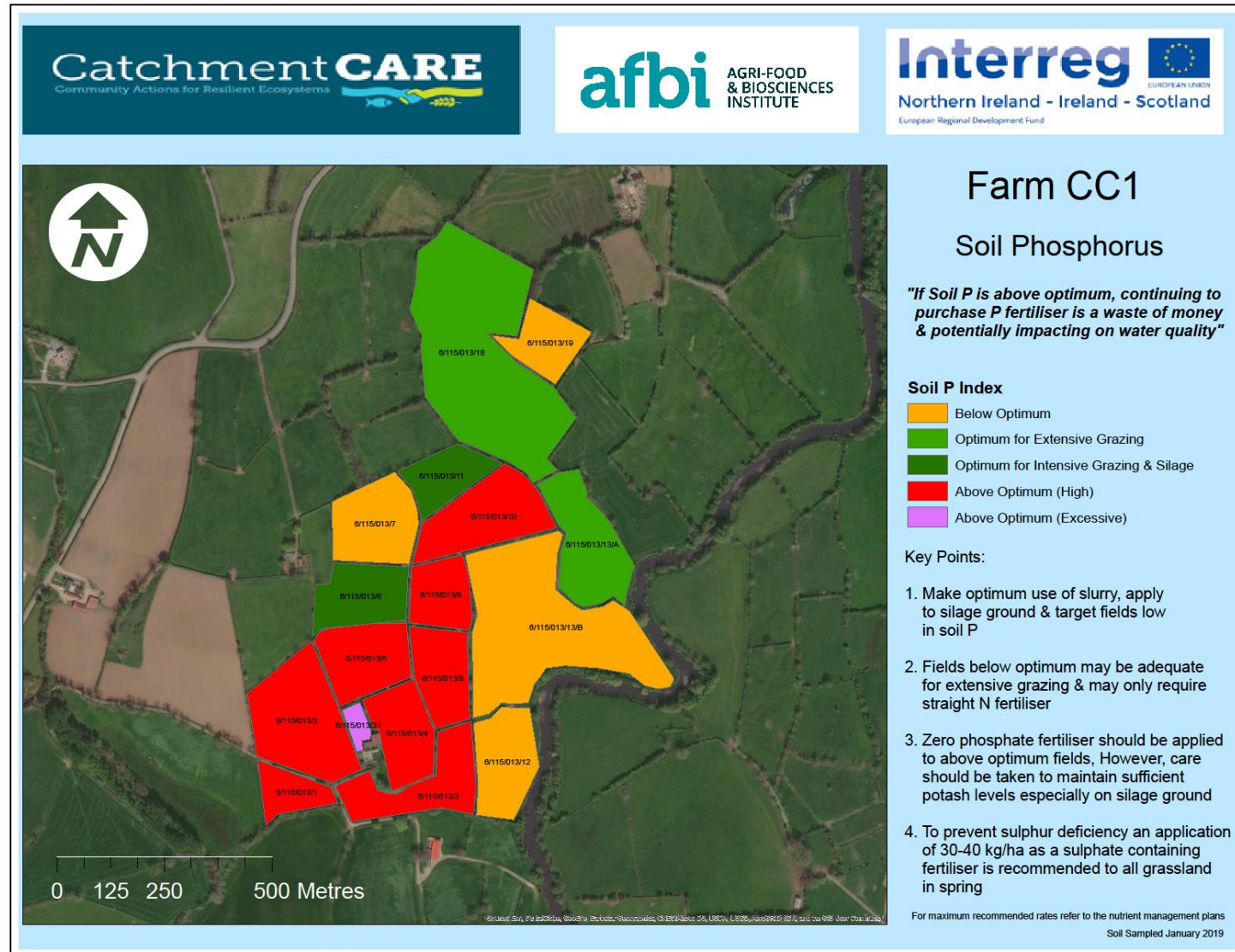
- 66% of fields sampled contained excessive soil P
- Above the agronomic optimum Index 2
- Higher than the national average

Soil P Index of 400 fields in Blackwater Catchment



# Knowledge Transfer

- Production of nutrient management plans for 17 farms
- Red = Above optimum
- Green = Optimum
- Yellow = Below Optimum





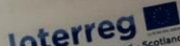
# Knowledge Transfer

- Calculation of farm P balances
- Recommendations for improved fertiliser and slurry management

**CatchmentCARE Nutrient Management Practices**  
To refine the current nutrient advice to farmers through the implementation of farm scale studies

**afbi** Agri-Food and Biosciences Institute  
**Farm Records**

Farmer .....  
Address .....

Supported by **Interreg** 

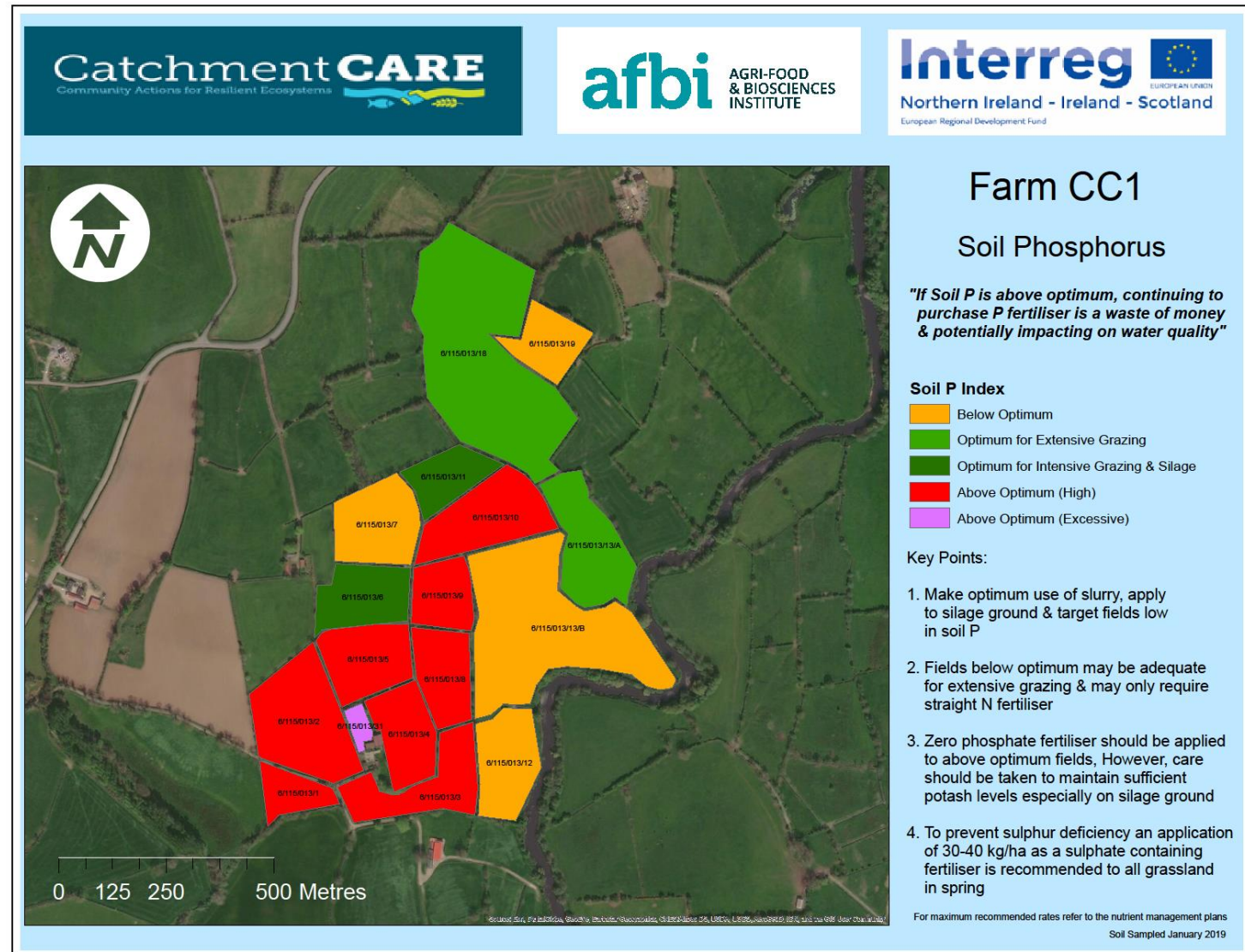
**EXAMPLE- SILAGE FIELDS**  
You can use imperial or metric units – just remember to include rates

Field numbers: 1,2,4,6, 7A      Total Area: 24ha

Date	Field Operation
10/02/19	2000 gals/ac cow slurry-watery
03/03/19	1 bag urea per acre (46%N)
08/04/19	2 bags 21-0-14-7 per acre
05/19	1 <sup>st</sup> cut silage mowed for wilting
15/19	1 <sup>st</sup> cut lifted
19	2000 gals/ac cow slurry
19	3 ½ bags 21-0-14-7 per acre
	2 <sup>nd</sup> cut silage mowed for wilting
	2 <sup>nd</sup> cut lifted
	1500 gals/acre cow slurry
	½ bags 21-0-14-7 per acre
	1 cut silage mowed for wilting

# Knowledge Transfer

- In response to the nutrient plans, a 42% reduction in P applied through inorganic fertiliser has been recorded





# Grass silage quality and nutrient balance

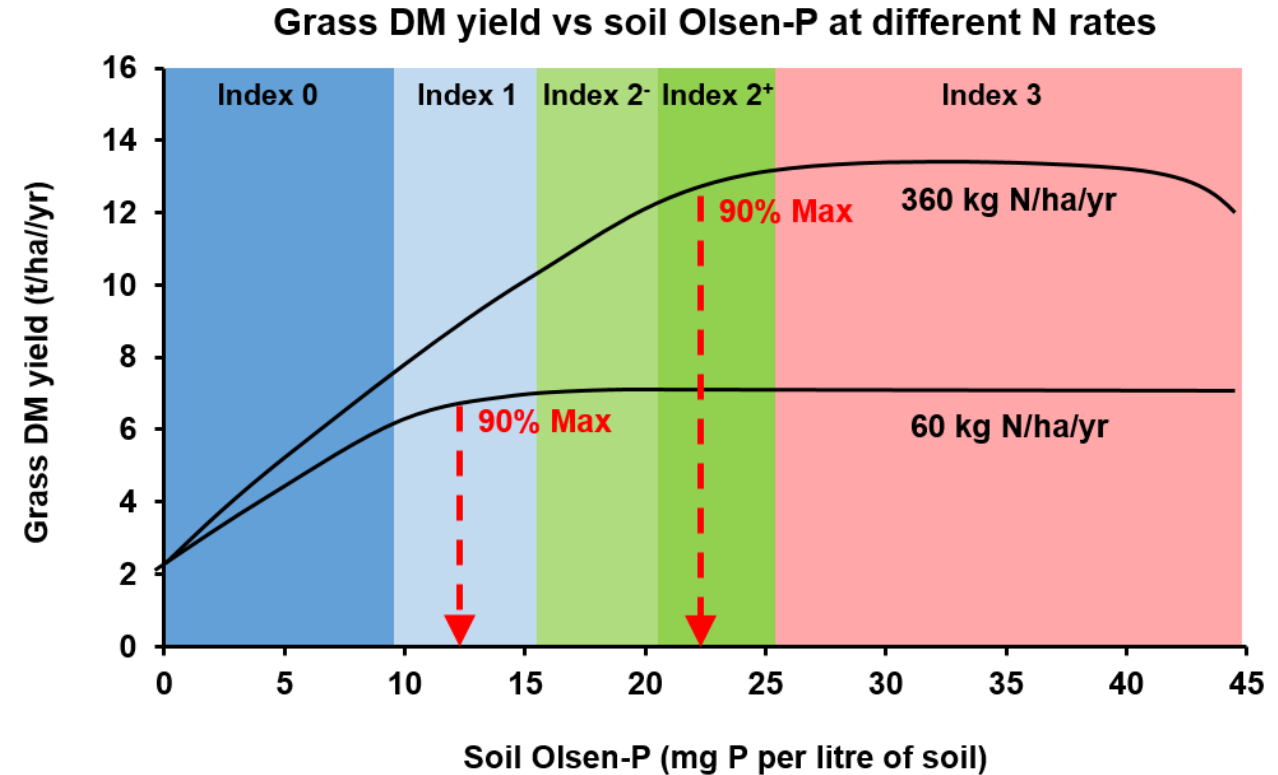
- Reassurance that grass is receiving sufficient nutrients





# Evaluating P recommendations for extensively managed grasslands within the revised Nitrates Action Programme (NAP)

- Based on the lower N inputs to extensively managed systems and lower target yields, new P recommendations were formulated for extensively managed grassland
- Included in the 2019 – 2022 Nitrates Action Programme and P Regulations





# Revisions to the 2019-22 NI Nutrients Action Programme and P Regulations

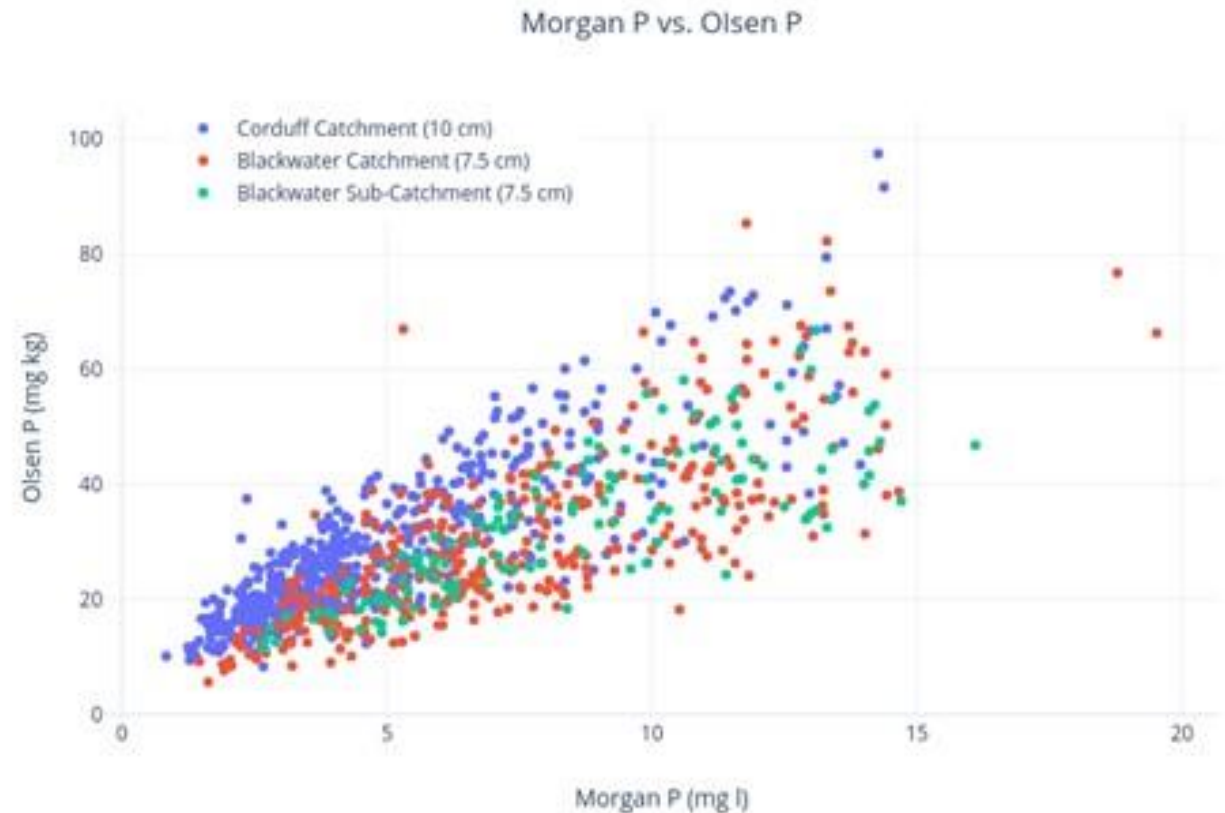
Index	Olsen P UK	Status	Morgan's P Rol	Status
0	0 – 9	Deficient		
1	10 – 15	Low	0 - 3	Very low
2-	16 – 20	Optimum for extensive grasslands	3.1 - 5	Low
2+	21 – 25	Optimum for intensive grasslands		
3	26 – 45	High	5.1 - 8	Medium (Optimum)
4	46 - 70	Excessive	≥8	High



# Comparison between current NI and RoI Olsen and Morgan's extractable soil tests

- Two different soil P tests operating in close proximity in cross border areas
- Do the recommendations derived from each test vary significantly
- Could choice of soil test impact on water quality in cross border areas e.g. difference between Index 3 and Index 2

Vero et al. 2021

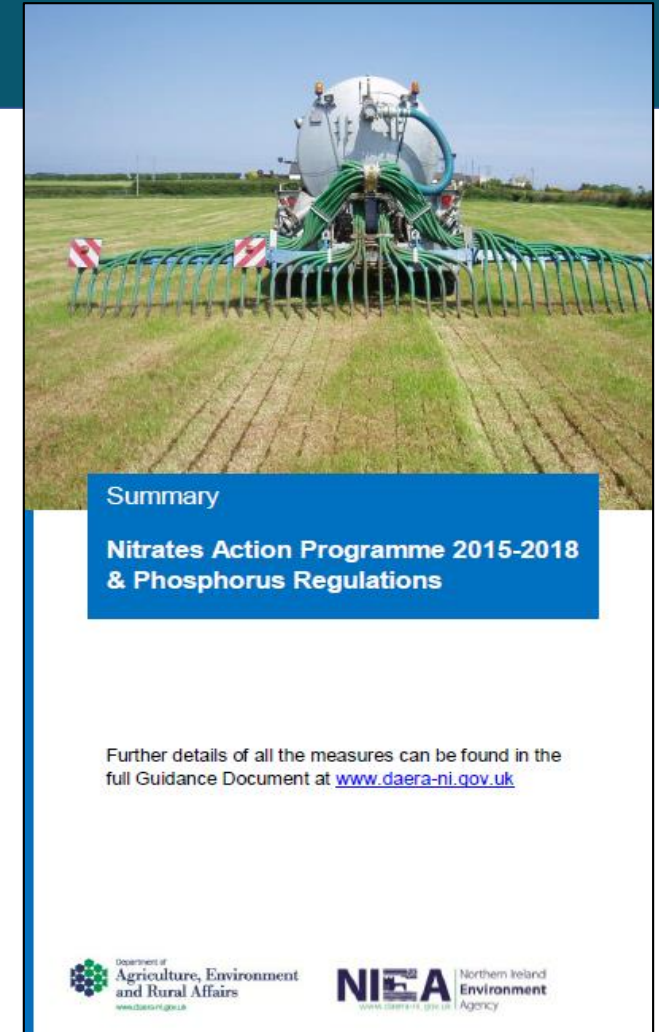




# Revisions to the 2019-22 NI Nutrients Action Programme and P Regulations

NI System	Fertiliser recommendations kg P <sub>2</sub> O <sub>5</sub> /ha					
	0	1	2-	2+	3	4
Grass establishment	80	65	50	30	0	0
Grazed grass (whole season)	50	35	20	0	0	0
First cut silage	70	55	40	0	0	0
Hay	55	43	30	0	0	0

Target index for grazed fields Index 2-, Lower P fertiliser inputs  
 Silage fields target Index 2+, Higher N inputs, Higher P inputs



# P Rate Experimental Plots



**Treatments:** 3 rates P plus zero P control plots 6 reps of each = 60 plots  
Grass Yield 2 cuts per year; Grass Quality



# Results: Farm 1 Low soil P (Index 1)

P Applied	Annual yield (2 cuts) t/ha	
	2019	2020
Grazing 35 kg P2O5 / ha whole season	7.3	4.0
Silage 1st Cut 55 kg P2O5/ha 2 <sup>nd</sup> Cut 20 kg P2O5/ha	7.7	4.7
No P Applied	6.9	3.5





# Results: Farm 2 Optimum soil P for grazing (Index 2-)

P Applied	Annual yield (2 cuts) t/ha	
	2019	2020
Grazing 20 kg P2O5 / ha whole season	6.9	7.2
Silage 1st Cut 40 kg P2O5/ha 2 <sup>nd</sup> Cut 15 kg P2O5/ha	7.2	7.8
No P Applied	6.5	6.4





# Results: Farm 3 Optimum soil P for grazing (Index 2-)

P Applied	Annual yield (2 cuts) t/ha	
	2019	2020
Grazing 20 kg P2O5 / ha whole season	6.3	6.3
Silage 1st Cut 40 kg P2O5/ha 2 <sup>nd</sup> Cut 15 kg P2O5/ha	7.3	8.3
No P Applied	5.8	5.0



# Discussion

- The revised P recommendations for extensive grassland are appropriate
- No P deficiency was found in grass samples collected from the plots receiving P
- Some signs of grass P deficiency in control plots where no P applied
- Important to apply P if Index 0, 1, 2-, to protect animal health in a grazing system and to ensure good silage yields





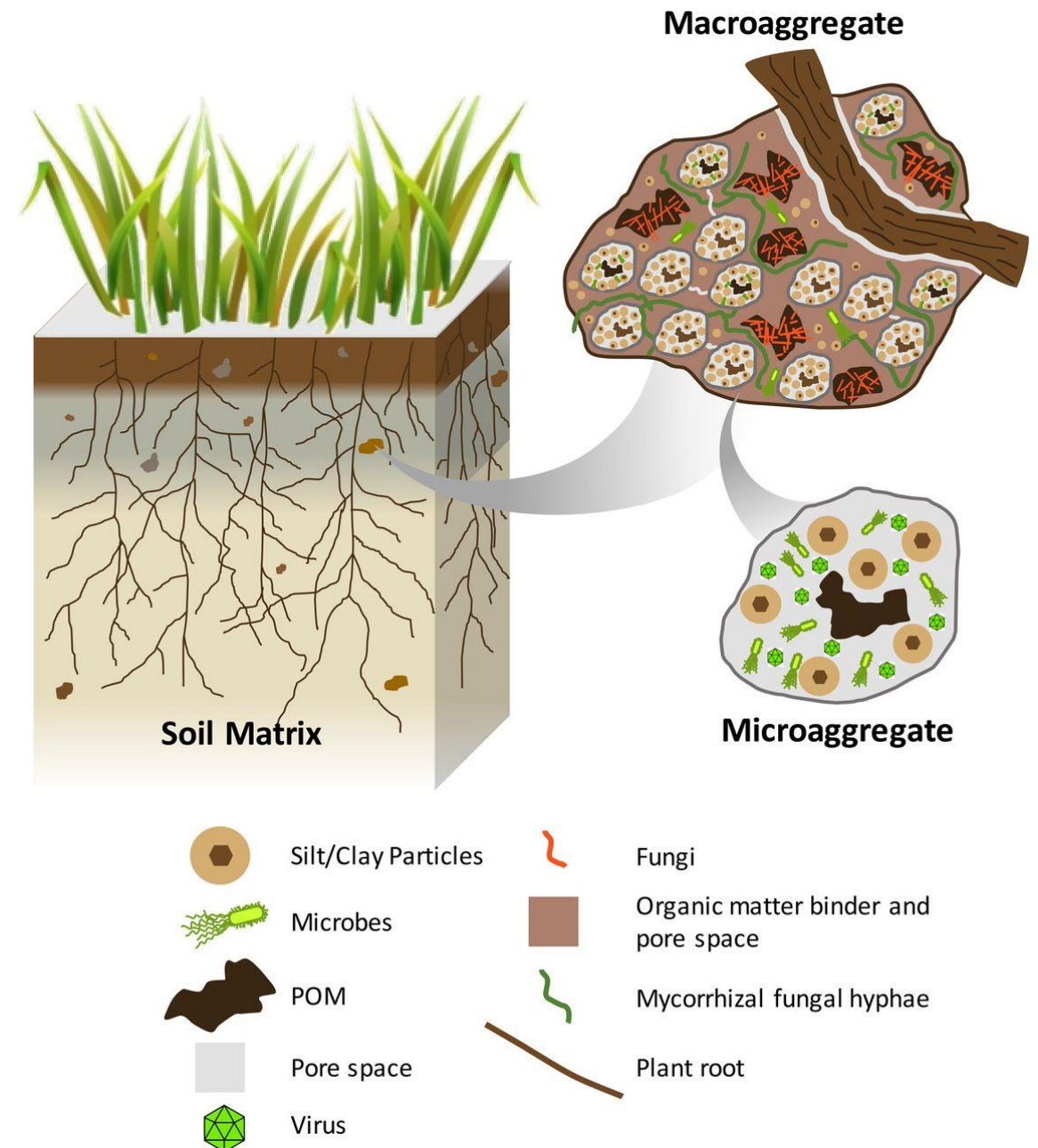
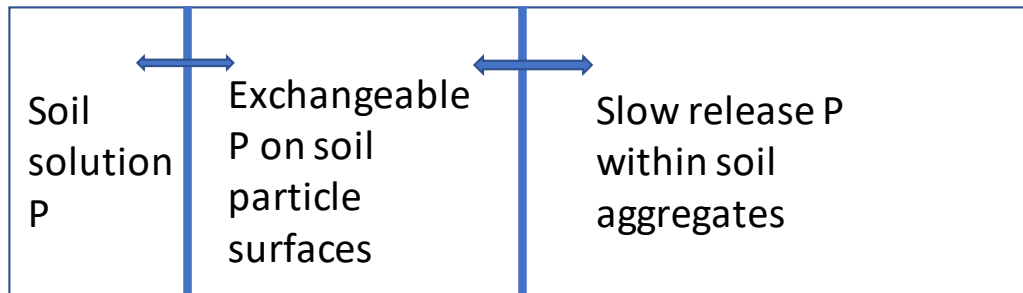
# Discussion

- Supporting literature: Nawara et al. 2018 Belgium showed that the higher the N input, the greater the growth and demand for P also increases. P deficiency would be more common in high N-input systems
- For high P soils (Index 3 – 4+) need to reduce these to Index 2 (or Index 1)
- Previous studies (Bailey, 2015) have demonstrated that it can take up to 13 years for an Index 4 soil to decline to Index 2 under a zero-P grazing regime
- 8 years under a zero-P silage regime

Nawara et al. 2018 European Journal of Soil Science 69, 804-815

# Plant available P

Reducing P inputs while meeting grass demand for readily available P, particularly in silage systems during rapid growth in spring.



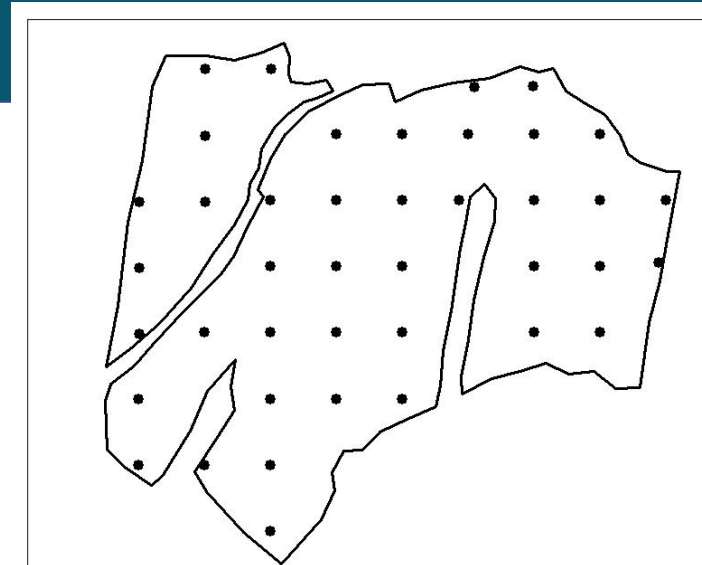


# Targeted in-field management and new technology

- Fields are generally managed as uniform units
- Research has shown substantial sub-field scale variability in plant nutrients P, K, Mg, S, nitrogen availability and soil pH
- Sub-field scale monitoring is currently too costly to implement widely but new technology is presenting opportunities

# Targeted in-field management

Hayes et al 2021



Scale: 1:1,800

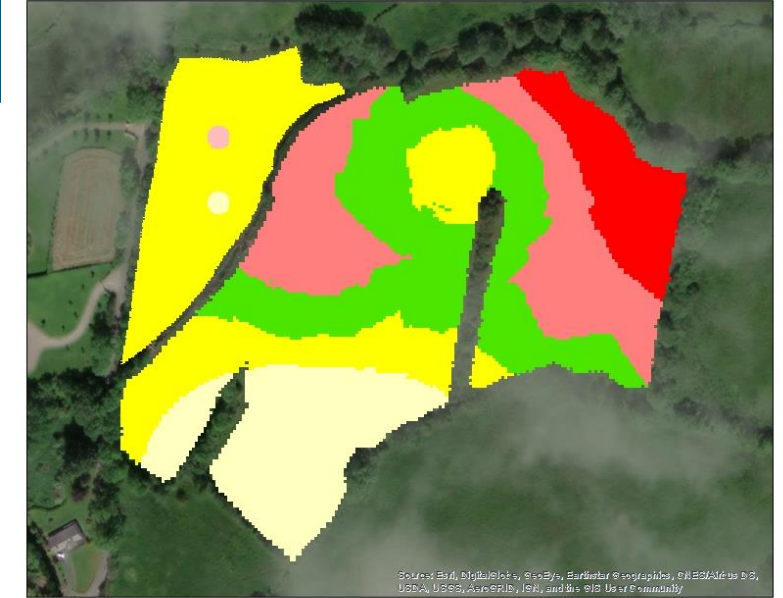
0.01 0.035 0.07 0.105 0.14 Kilometers



## Legend

• Soil Sampling Point

Field Boundary (bordered by hedgerows or a river system)



Scale: 1:1,900

0.01 0.035 0.07 0.105 0.14 Kilometers



## Legend

### Soil P Index

Index 2

Index 0

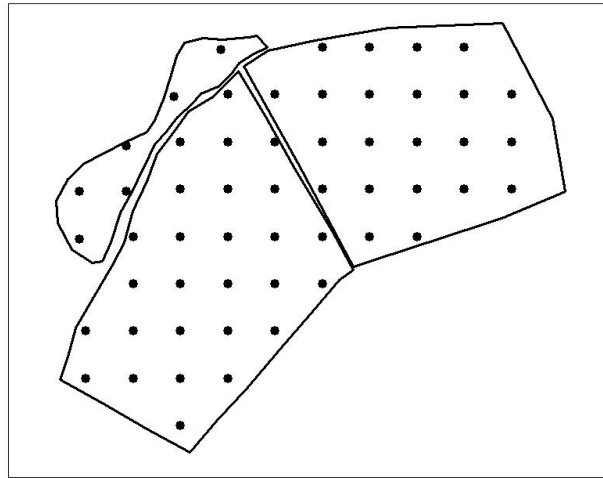
Index 3

Index 1

Index 4



# Targeted in-field management



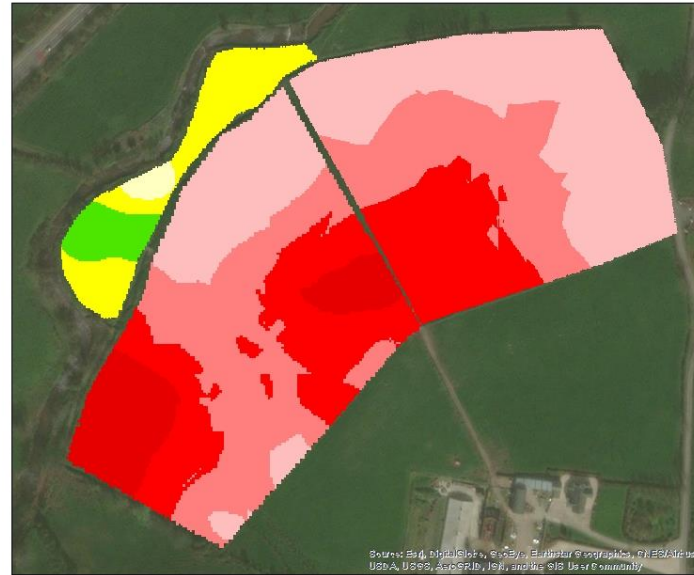
Scale: 1:2,500

0 0.02 0.04 0.08 0.12 0.16 Kilometers



## Legend

- Soil Sampling Point
- Field Boundary (bordered by hedgerows or a river system)



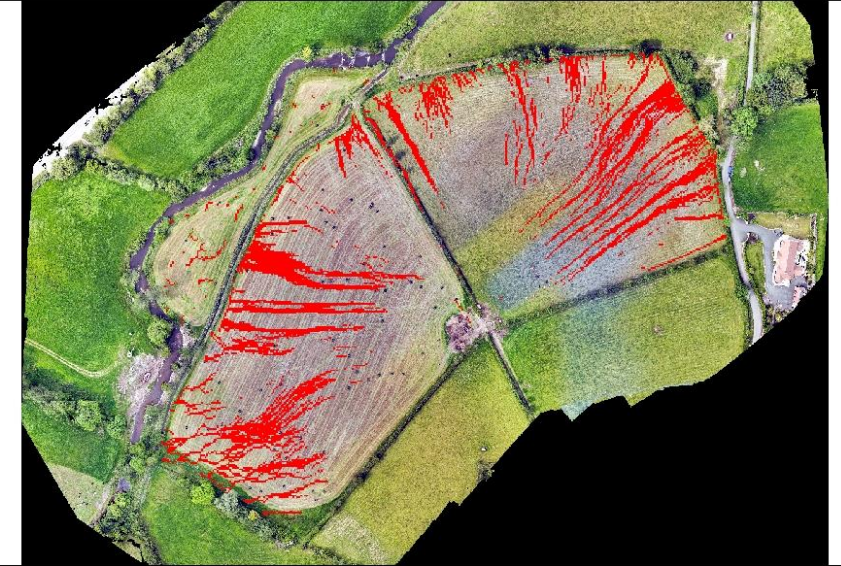
Scale: 1:2,000

0.01 0.03 0.05 0.07 0.10 0.14 Kilometers



## Legend

- | Soil P Index |         |
|--------------|---------|
| Yellow       | Index 0 |
| Light Yellow | Index 1 |
| Green        | Index 2 |
| Light Red    | Index 3 |
| Red          | Index 4 |
| Dark Red     | Index 5 |
| Dark Red     | Index 6 |



Scale: 1:1,600

0 0.03 0.06 0.12 0.18 0.24 Kilometers

## Legend

### Modelled Runoff Channels



# Conclusions

- Farm-specific nutrient management is essential for reducing nutrient surpluses
- Field scale nutrient management plans are very effective communication tools
- Extensively managed grasslands may still maintain productivity at lower P inputs



Catchment CARE thanks the 17 farmers in the Blackwater Catchment who are involved in this study

Catchment **CARE**  
Community Actions for Resilient Ecosystems

