Scale of N Leaching - What, Where & When



Nitrates Directive
Derogation Training

teagasc
Agriculture and Food Development Authority

An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine

Different Types of Water

- Soil water - Leaving the root zone – Suction cups / Lysimeters
- Ground water – Below the Water Table – Well sampling
- River water - Auto & grab samples and discharge (volume)
- Estuarine - Discharge from River into the Sea – how salty ?
- Coastal - Nitrate Concentration, Eutrophication & Impact

Nutrient Load (Kg.) (Delivery) vs. Concentration (mg/l) (Impact)


0
50
100km
Algal bloom
SWEDEN
North Sea
POLAND
UK
GERMANY
LATVIA
BALTIC SEA
SWEDEN
LITHUANIA
Algal bloom
RUSSIA
POLAND
SOURCE: ESA, 11 JULY

Algae Bloom on a beach on the south coast of Ireland

Source: EPA

S O’Boyle photograph

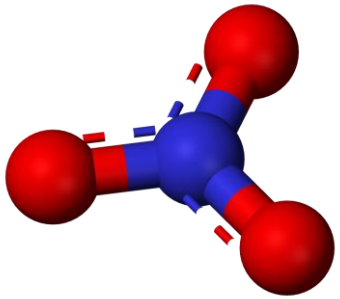


What Units are we using?

MPG vs litres/100km

Nitrate (NO_3^-)

- 50 mg/l
- 37.5
- 11.5
- 8
- 4

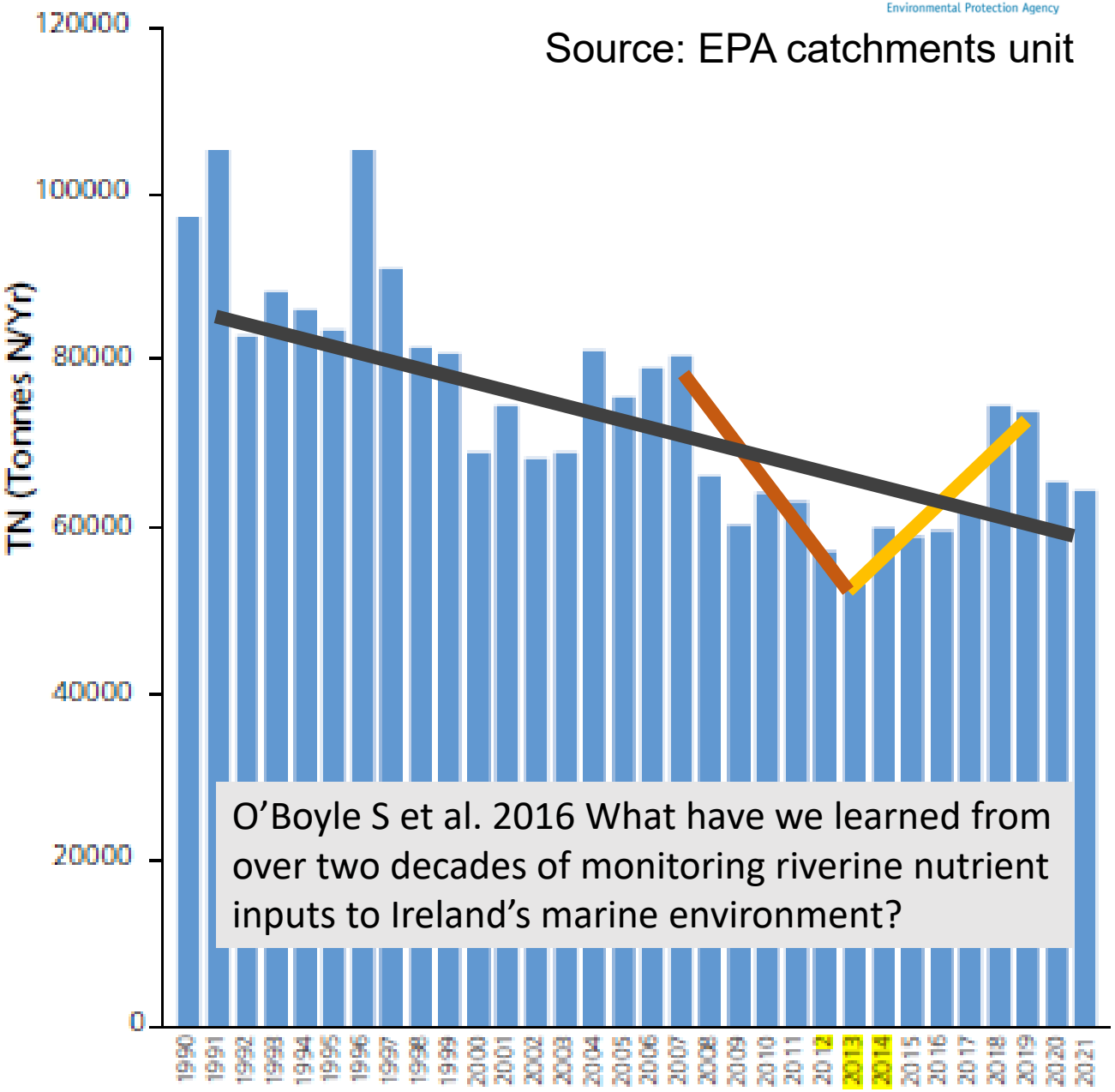


N

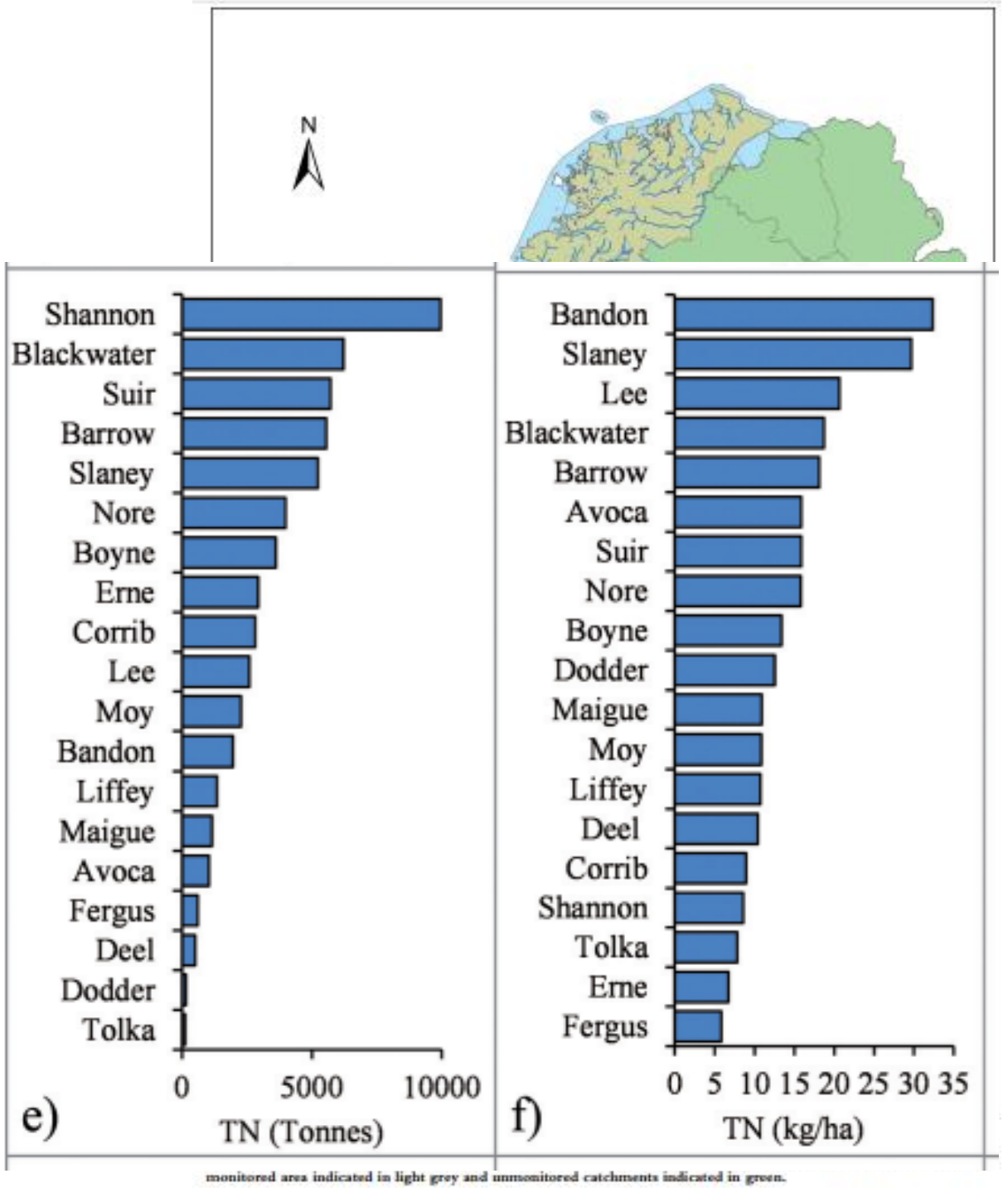
- 11.3 mg/l Drinking MAC
- 8.5 (75% of MAC – avg.)
- 2.6 Marine Ecological Standard
- 1.8 EPA indicator River – good
- 0.9 EPA indicator River - high

Total Nitrogen Loads

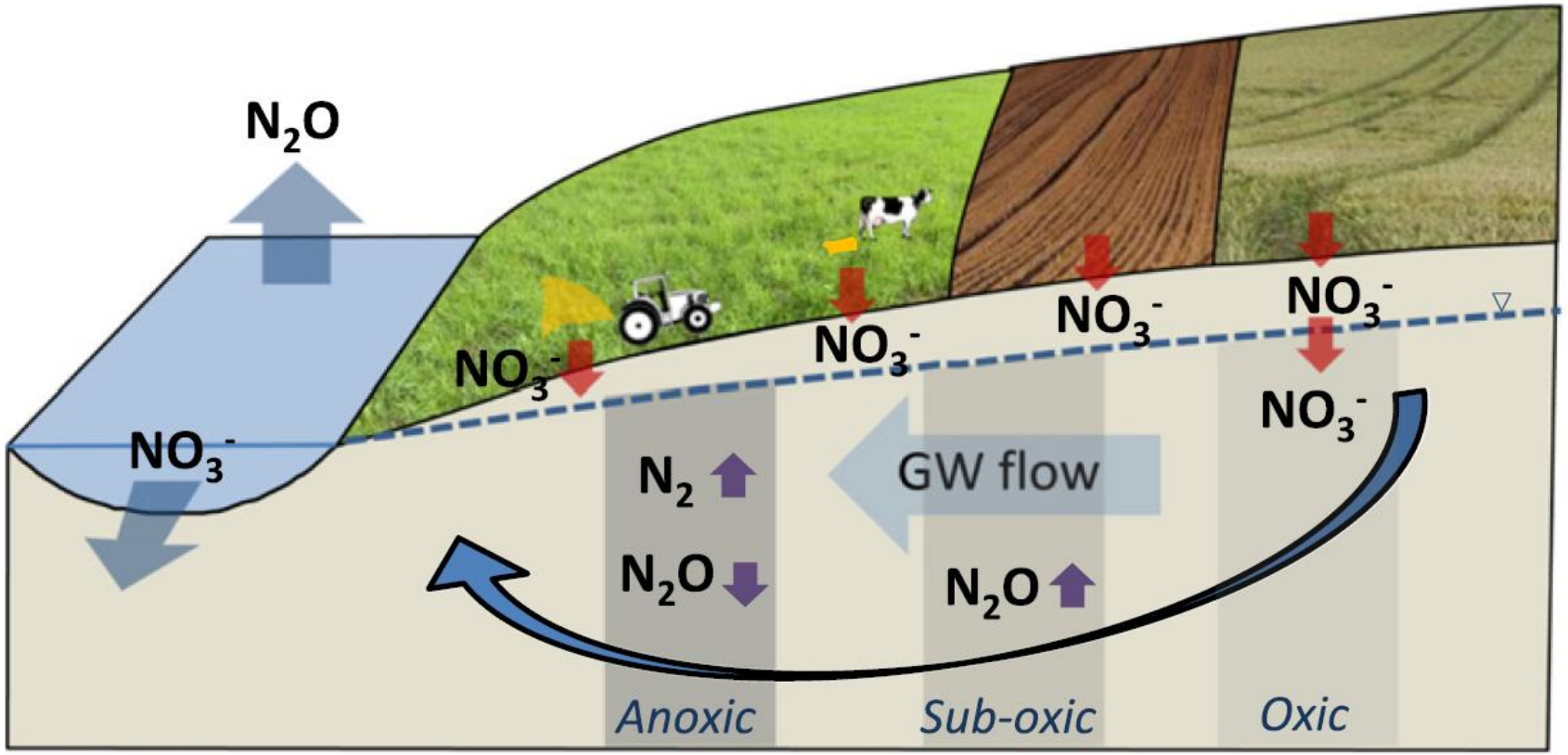
Source: EPA catchments unit



O'Boyle S et al. 2016 What have we learned from over two decades of monitoring riverine nutrient inputs to Ireland's marine environment?



Nitrate Leaching Pathway



[McAleer et al., STOTEN 2017]

- **A variety of soil types**
- **N removal capacity varies highly between and within catchments**
- **Transformation processes occur along the pathway from the rooting zone to surface water**
- **Poor link between N leaving the root zone and N in the stream**

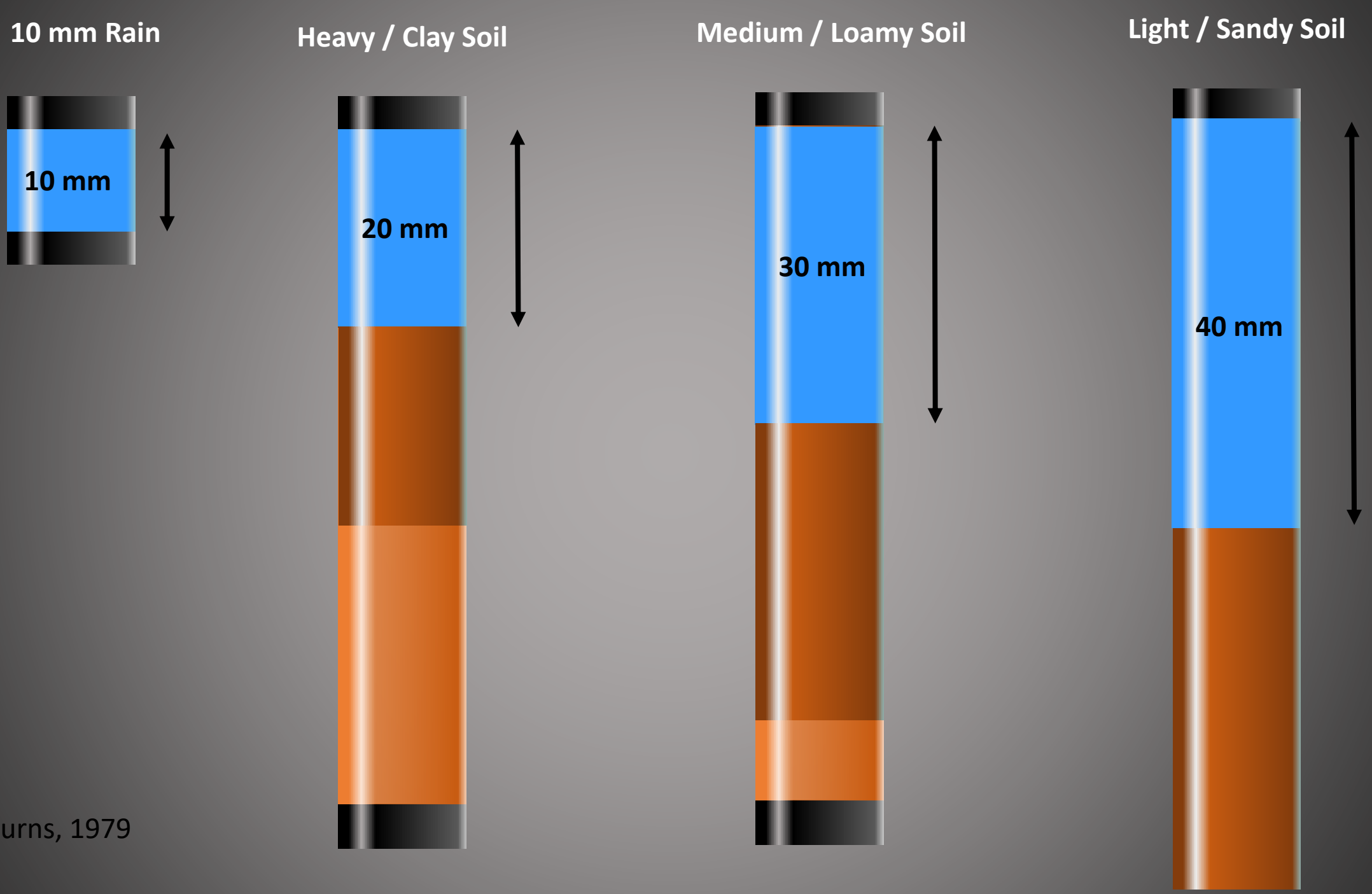
2 factors influence the amount of N leached

1. Amount of water passing through the soil profile
   - excess of rainfall over evapotranspiration
2. Concentration of nitrate in soil at the onset of leaching

10 cm of rainfall will displace a much greater depth of soil moisture in a sandy soil compared to a clay soil.

Soil Texture	Mean Displacement (cm)
Sandy	45
Medium	30
Clay	20

Burns, 1979


10 mm Rain
Heavy / Clay Soil
Medium / Loamy Soil
Light / Sandy Soil
10 mm
20 mm
30 mm
40 mm
Burns, 1979

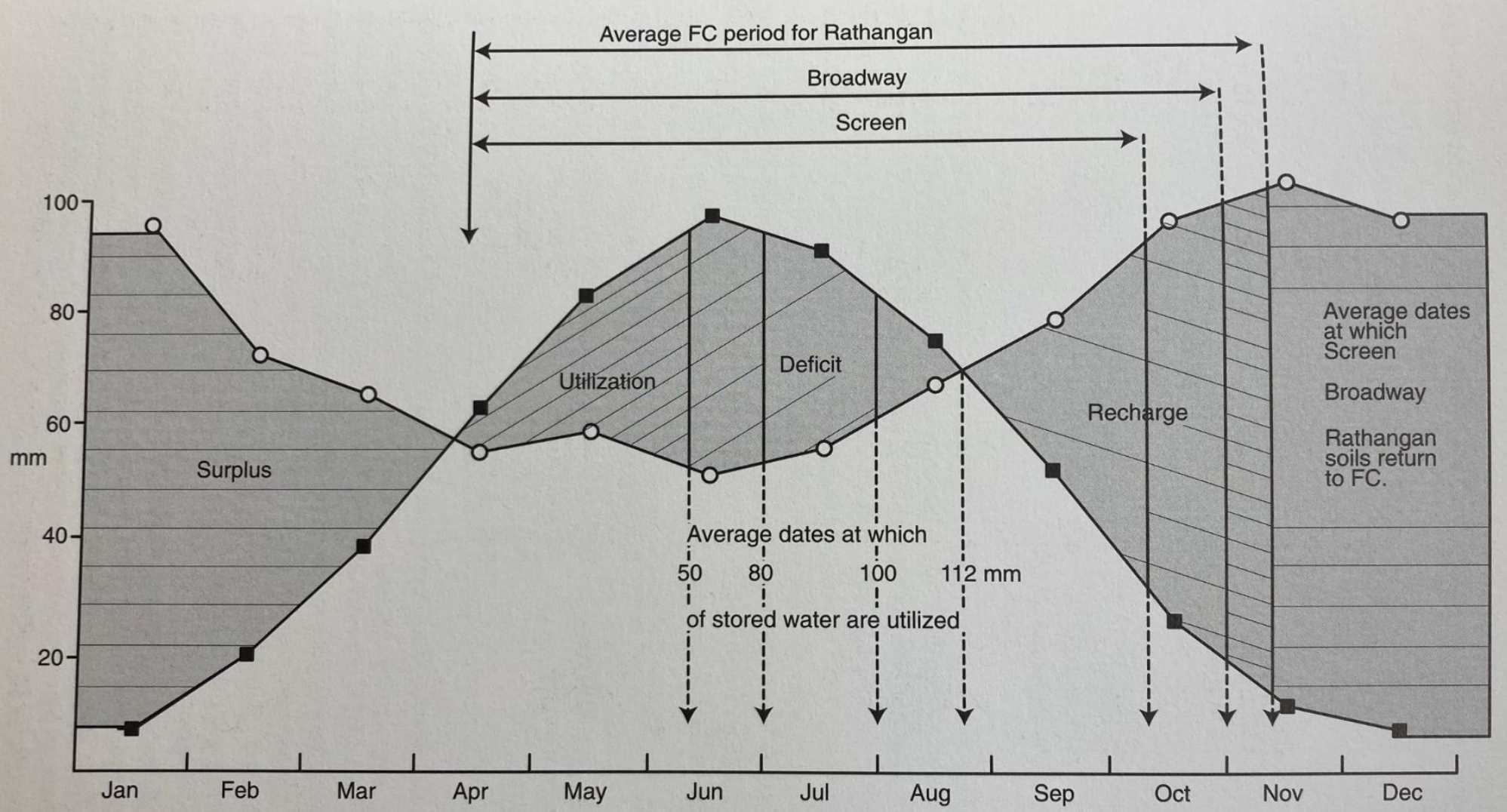
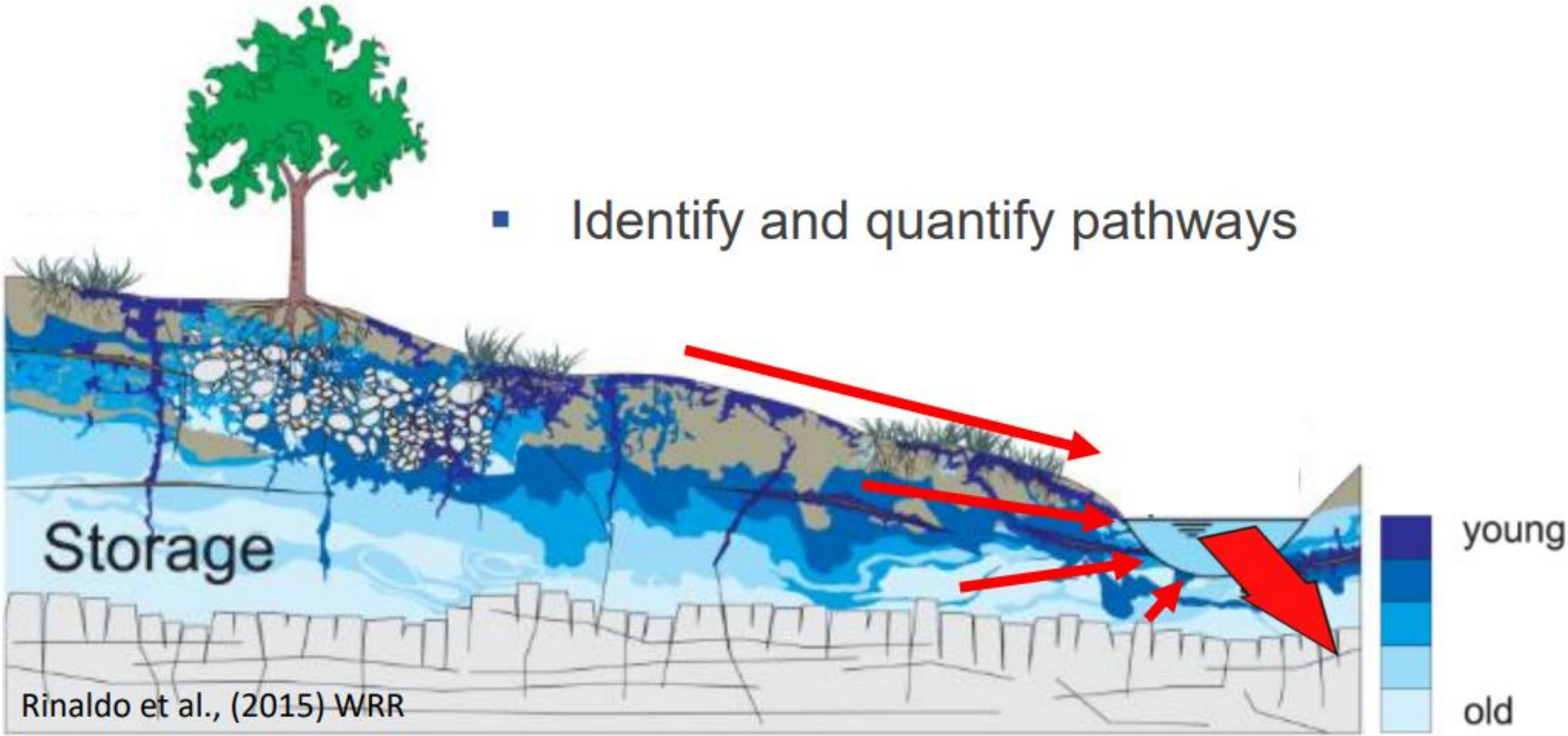


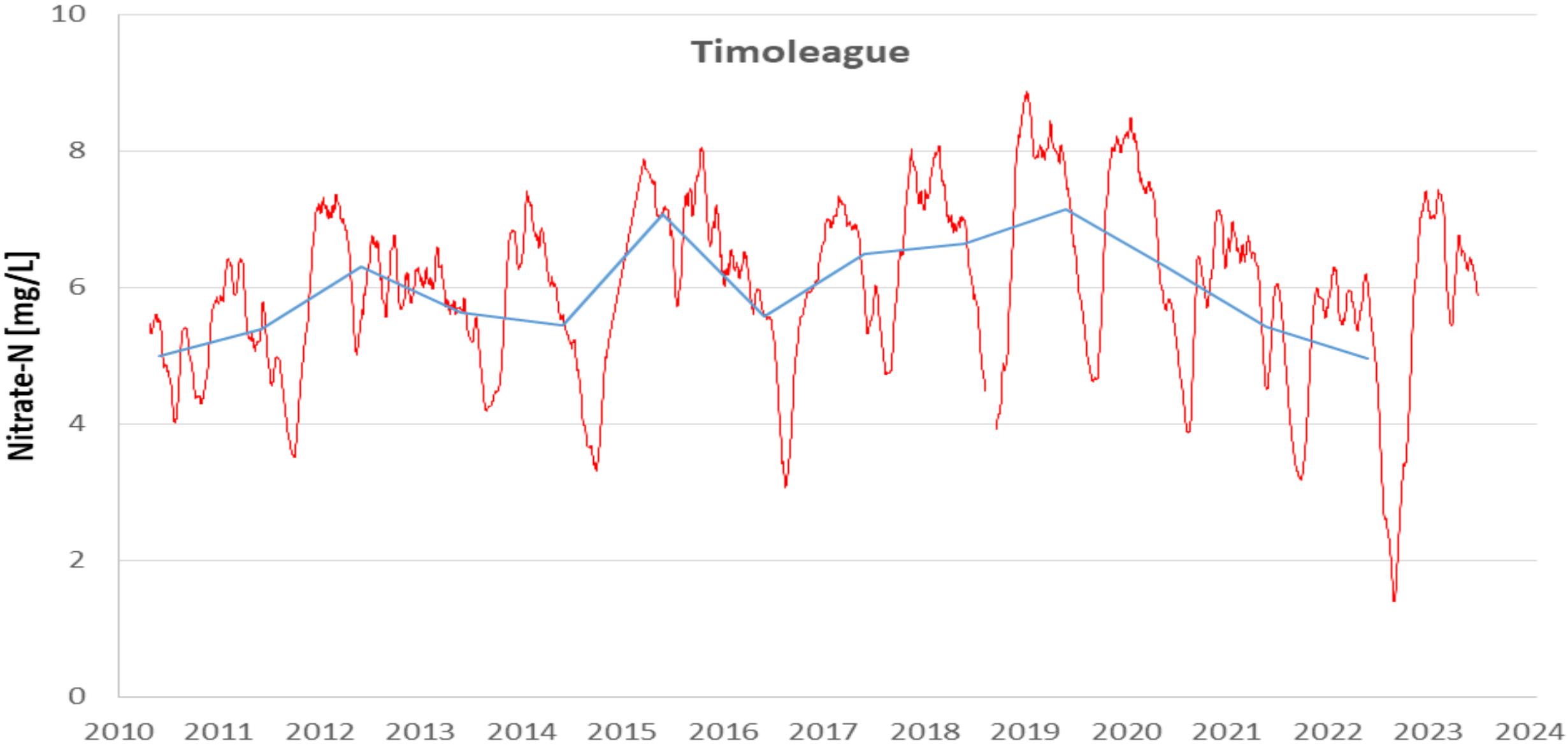
Fig 6.4 Average annual soil-water relations in three South Co. Wexford soils based on precipitation (O-O) and evapotranspiration (■-■) data for Rosslare (1958-82) and on the following calculated values for AWC: Broadway 90 mm, Rathangan 115 mm and Screen 45 mm.

Keane & Collins, 2004, Climate, Weather and Irish Agriculture

- Identify and quantify pathways



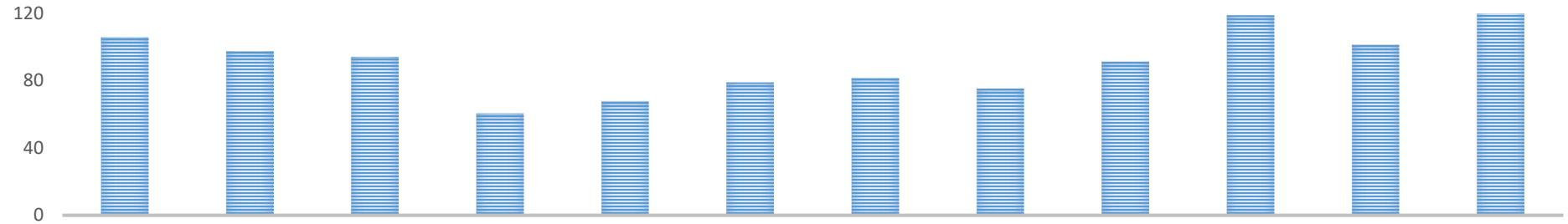
Rinaldo et al., (2015) WRR



AGRICULTURAL CATCHMENTS PROGRAMME

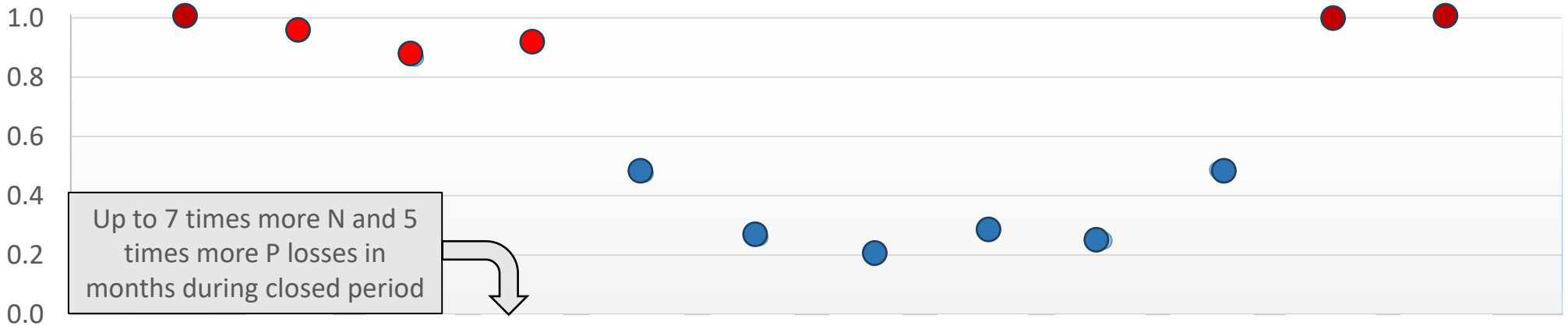
Timoleague

Rainfall generated 4 times more discharge in winter than in summer





Source: Dr. Per-Erik Mellander, Agricultural Catchments Programme, Johnstown Castle, Teagasc

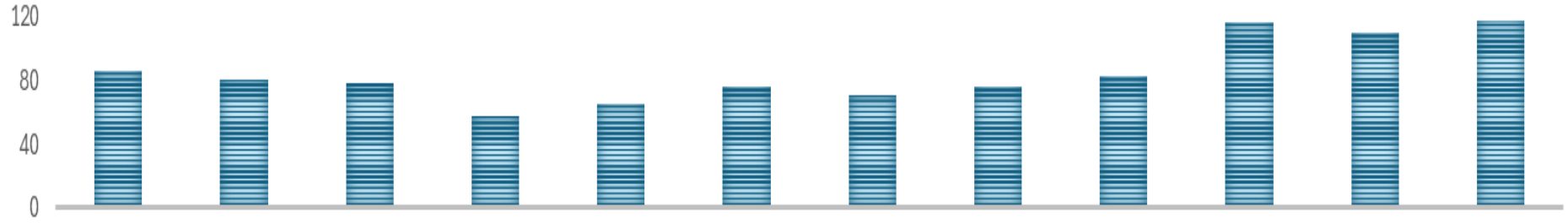


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly N Kg/ha:	**7.92**	**5.54**	**5.06**	**3.20**	**1.70**	**1.10**	**0.91**	**0.87**	**1.31**	**3.49**	**6.17**	**7.42**
% of Annual:	18%	12%	11%	7%	4%	2%	2%	2%	3%	8%	14%	17%
Monthly P Kg/ha:	**0.165**	**0.120**	**0.101**	**0.047**	**0.025**	**0.039**	**0.030**	**0.032**	**0.046**	**0.117**	**0.108**	**0.187**
% of Annual:	16%	12%	10%	5%	2%	4%	3%	3%	5%	12%	11%	18%

Annual Average
44.7 N
kg/ha/yr
1.02 P

Castledockrell

Rainfall generated 5 times more discharge in winter than in summer





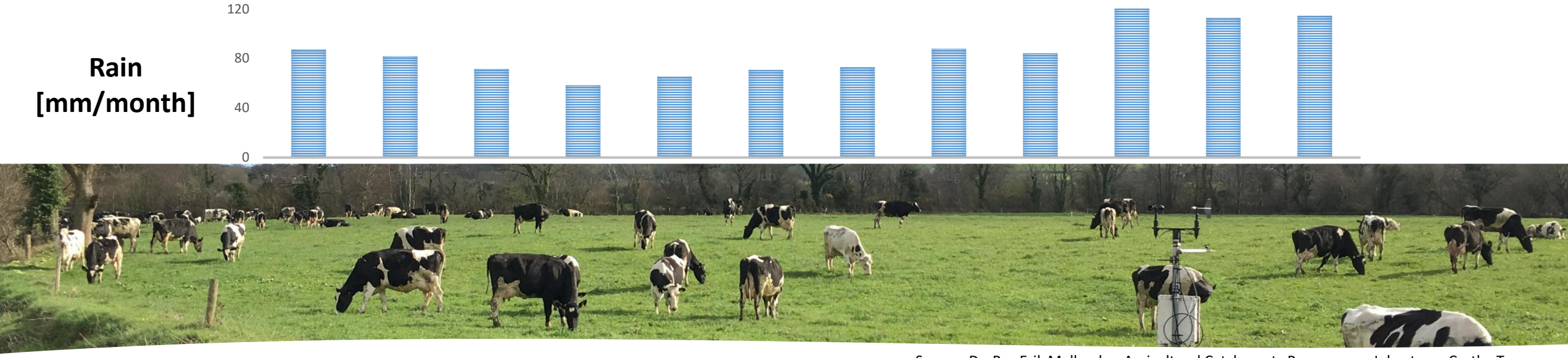
Source: Dr. Per-Erik Mellander, Agricultural Catchments Programme, Johnstown Castle, Teagasc



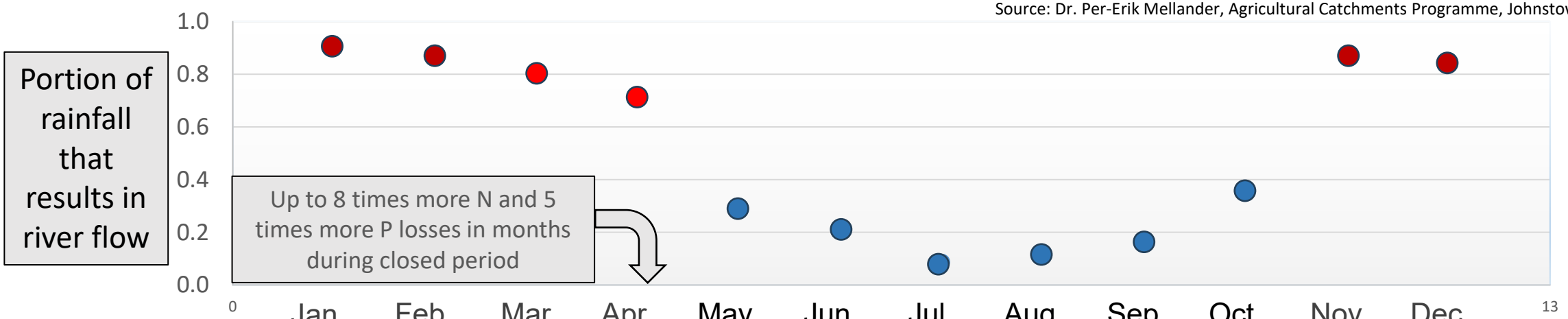
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Monthly N Kg/ha:	**5.84**	**4.85**	**4.01**	**2.43**	**1.56**	**1.20**	**0.71**	**0.79**	**1.00**	**2.50**	**5.50**	**6.24**	**36.6 N**
% of Annual:	16%	13%	11%	7%	4%	3%	2%	2%	3%	7%	15%	17%	kg/ha/yr
Monthly P Kg/ha:	**0.051**	**0.037**	**0.031**	**0.015**	**0.063**	**0.011**	**0.008**	**0.010**	**0.010**	**0.026**	**0.078**	**0.080**	**0.42 P**
% of Annual:	12%	9%	7%	4%	15%	3%	2%	2%	2%	6%	19%	19%	

Ballycanew

Rainfall generated 6 times more discharge in winter than in summer



Source: Dr. Per-Erik Mellander, Agricultural Catchments Programme, Johnstown Castle, Teagasc

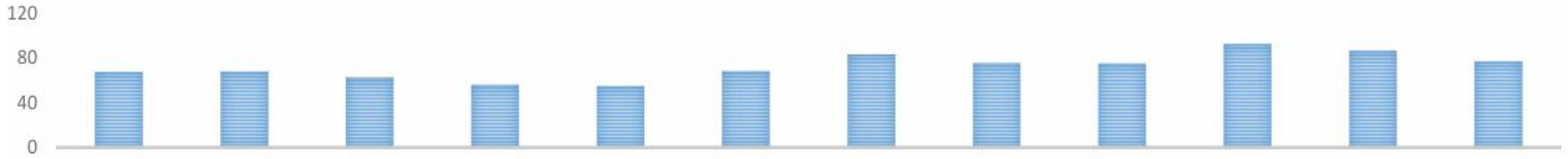


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Monthly N Kg/ha:	**1.82**	**1.47**	**1.35**	**0.86**	**0.59**	**0.38**	**0.16**	**0.35**	**0.43**	**1.60**	**2.66**	**2.56**	**14.2 N**
% of Annual:	13%	10%	9%	6%	4%	3%	1%	2%	3%	11%	19%	18%	kg/ha/yr
Monthly P Kg/ha:	**0.131**	**0.111**	**0.101**	**0.076**	**0.041**	**0.038**	**0.016**	**0.067**	**0.046**	**0.167**	**0.238**	**0.217**	**1.25 P**
% of Annual:	10%	9%	8%	6%	3%	3%	1%	5%	4%	13%	19%	17%	

Dunleer

Rainfall generated 7 times more discharge in winter than in summer

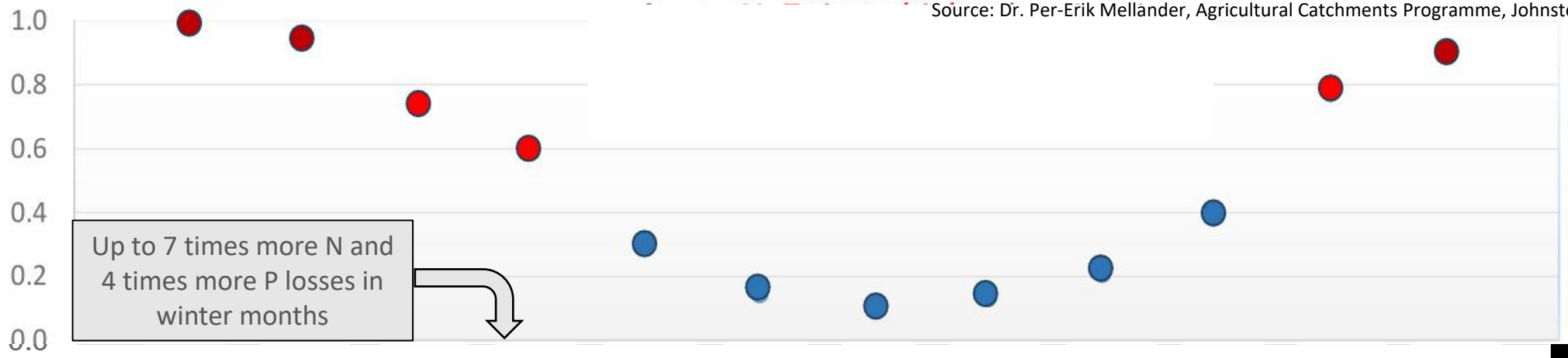
Rain [mm/month]





Source: Dr. Per-Erik Mellander, Agricultural Catchments Programme, Johnstown Castle, Teagasc

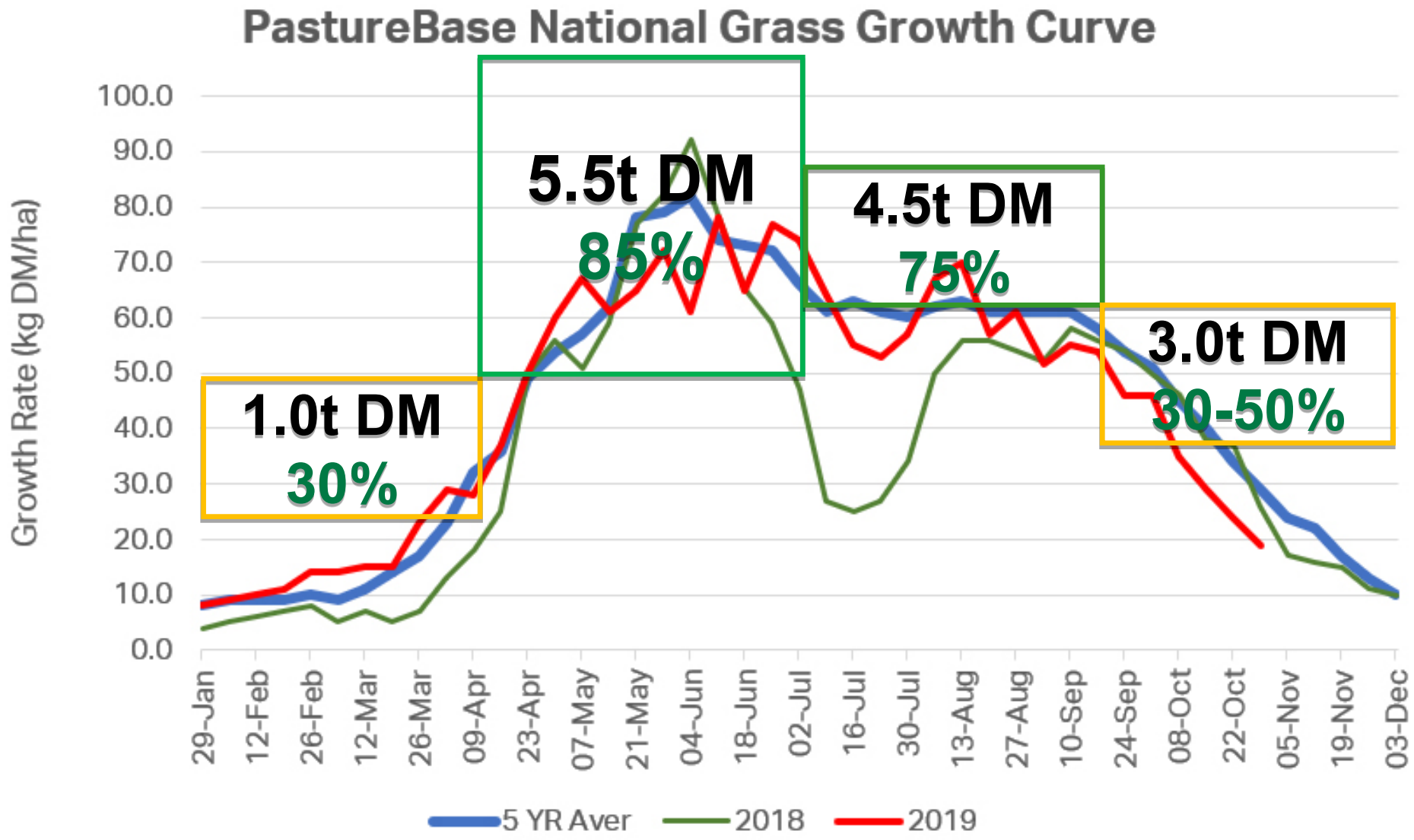
Portion of rainfall that results in river flow



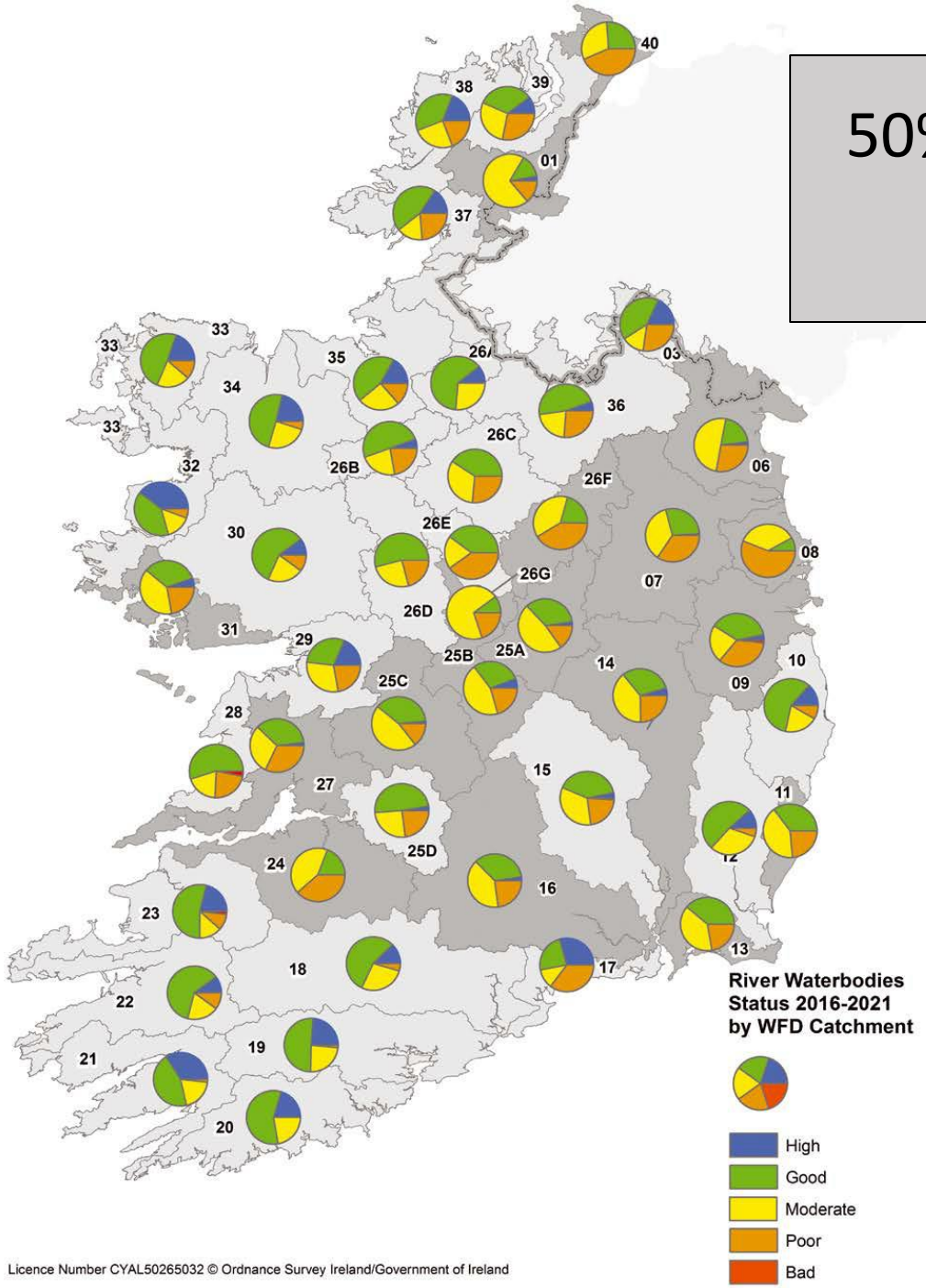
Up to 7 times more N and 4 times more P losses in winter months

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Monthly N Kg/ha:	**3.82**	**3.25**	**2.79**	**1.73**	**0.83**	**0.56**	**0.55**	**0.67**	**0.77**	**2.11**	**3.62**	**4.23**	**25 N**
% of Annual:	15%	13%	11%	7%	3%	2%	2%	3%	3%	8%	15%	17%	kg/ha/yr
Monthly P Kg/ha:	**0.12**	**0.128**	**0.106**	**0.048**	**0.029**	**0.027**	**0.037**	**0.041**	**0.051**	**0.15**	**0.199**	**0.113**	**1.05 P**
% of Annual:	11%	12%	10%	5%	3%	3%	4%	4%	5%	14%	19%	11%	

Grass Production & N Efficiency



Soil Fer

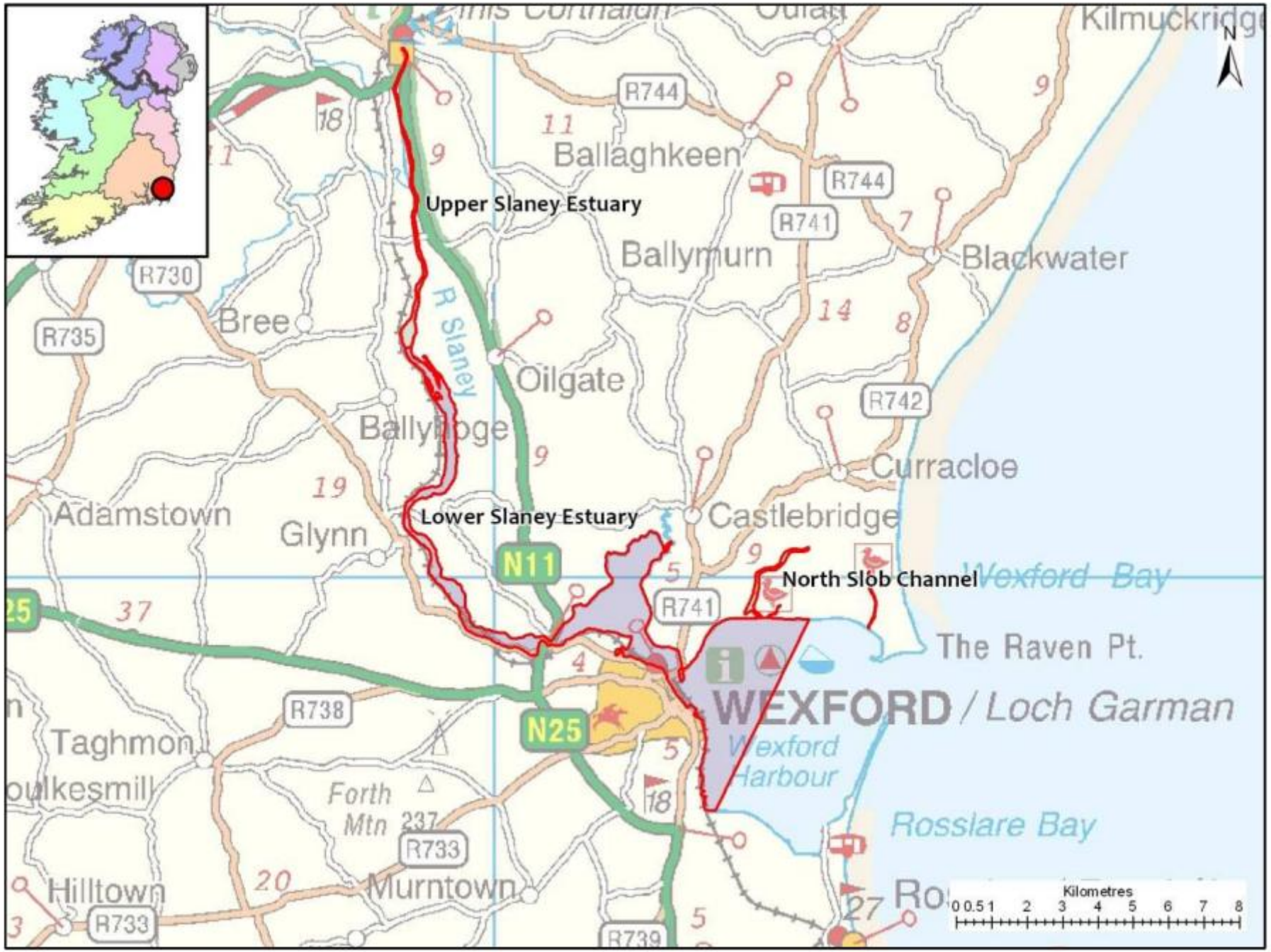


50% of river water bodies are High & Good &

50% are Moderate, Poor or Bad

What is Water Quality in the Slaney ?

- 95 monitoring points on the River Slaney
- 60 are High or Good 63%
- 35 are Moderate or Poor 37%



Source: The Central and Regional Fisheries Boards

N & P Balance: Efficient Use of Inputs

N & P inputs









- Fertiliser
- Meal/forage
- Livestock
- Slurry

Emissions



Losses to water

N & P outputs





- Milk
- Livestock
- Forage
- Slurry

- Inputs minus outputs = Farm gate N,P surplus (kg/ha/yr)

- Indicator of potential N,P pollution

Nutrient balance

National Farm Survey Sustainability Report 2024

	N	P
Dairy average balance (kg/ha/yr)	*165*	*9.6*
Future Target – dependent on SR	130	10
Cattle average balance(kg/ha/yr)	*54.6*	*3.3*
Nutrient use efficiency dairy (%)	*25.2*	*60.8*
Future Target	35-50	70
Nutrient use efficiency cattle (%)	*27.3*	*74.2*

Link between N balance and Nitrogen Leaching

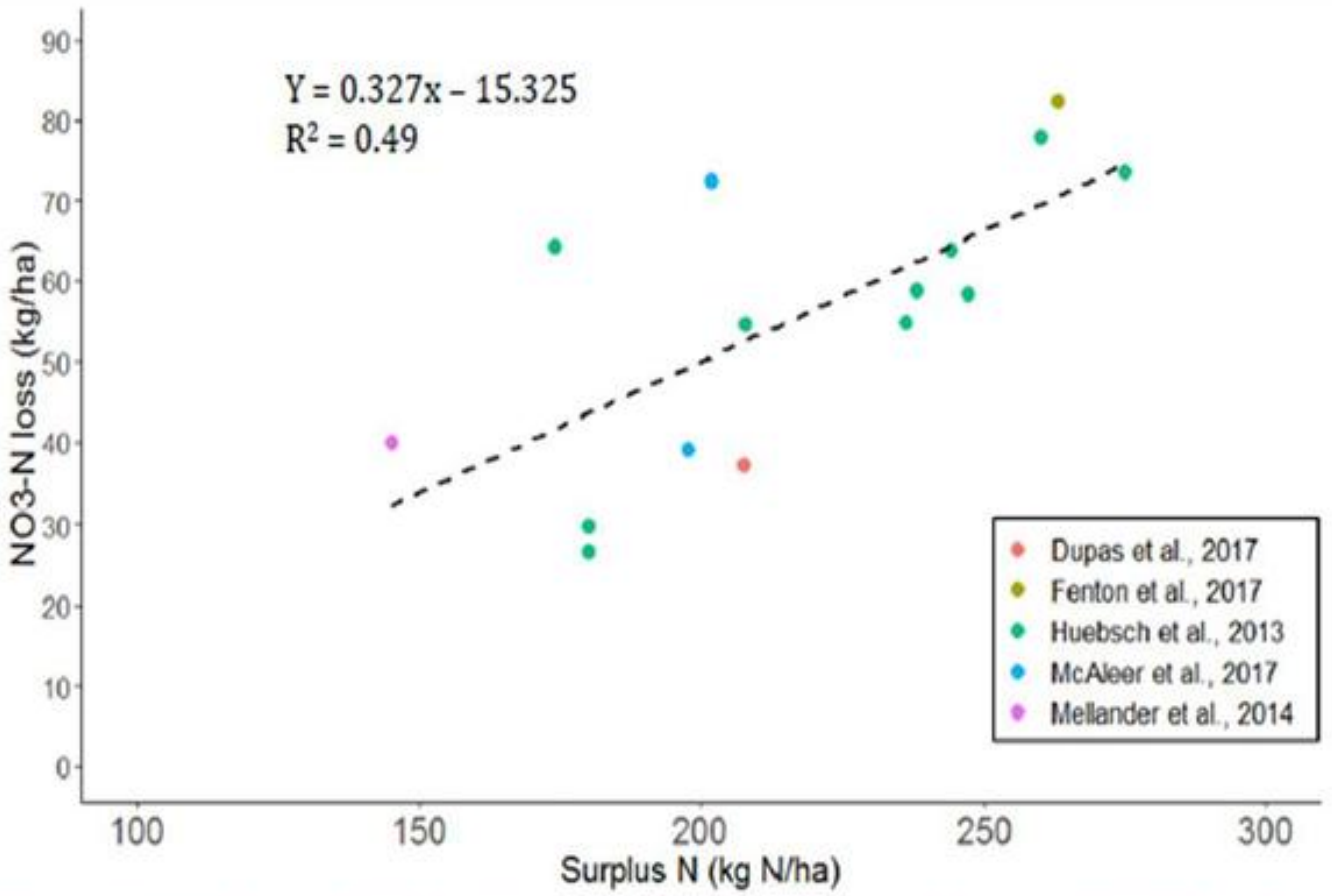
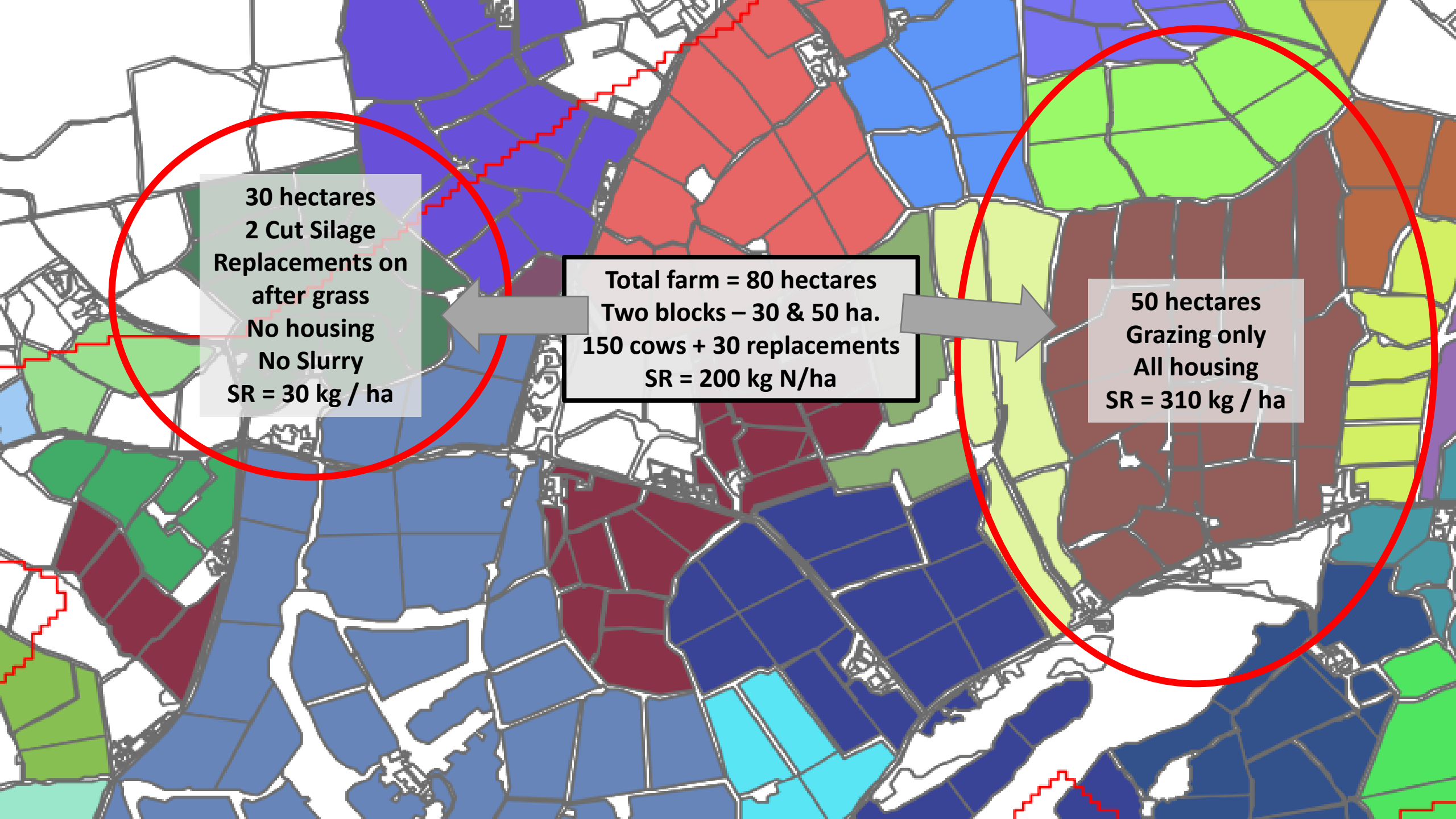
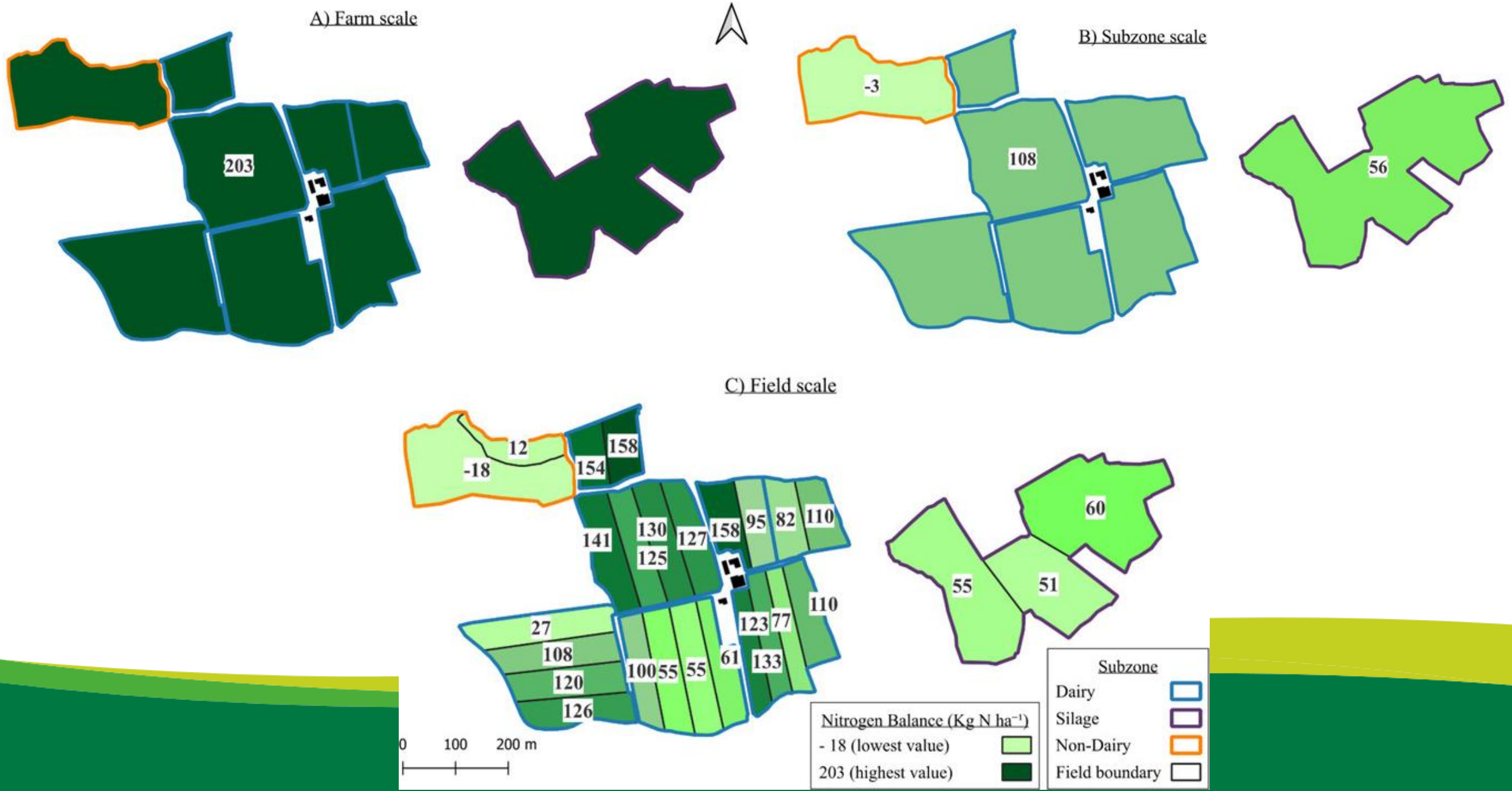


Figure 1.2. Relationship between surplus N and groundwater NO3-N loss from the reviewed literature on well-drained soils

- There is a strong correlation between nitrogen balance and nitrogen leaching
- Potentially Up to **30% of N surplus** can be lost to groundwater on well-drained soils


30 hectares
2 Cut Silage
Replacements on after grass
No housing
No Slurry
SR = 30 kg / ha
Total farm = 80 hectares
Two blocks – 30 & 50 ha.
150 cows + 30 replacements
SR = 200 kg N/ha
50 hectares
Grazing only
All housing
SR = 310 kg / ha

Importance of Nutrient Distribution



Factors that influence N soil content

- Nutrient Management
- Urine Patches
- Mineralisation
- Legumes
- Crop uptake / growing season
- Weather
- ????





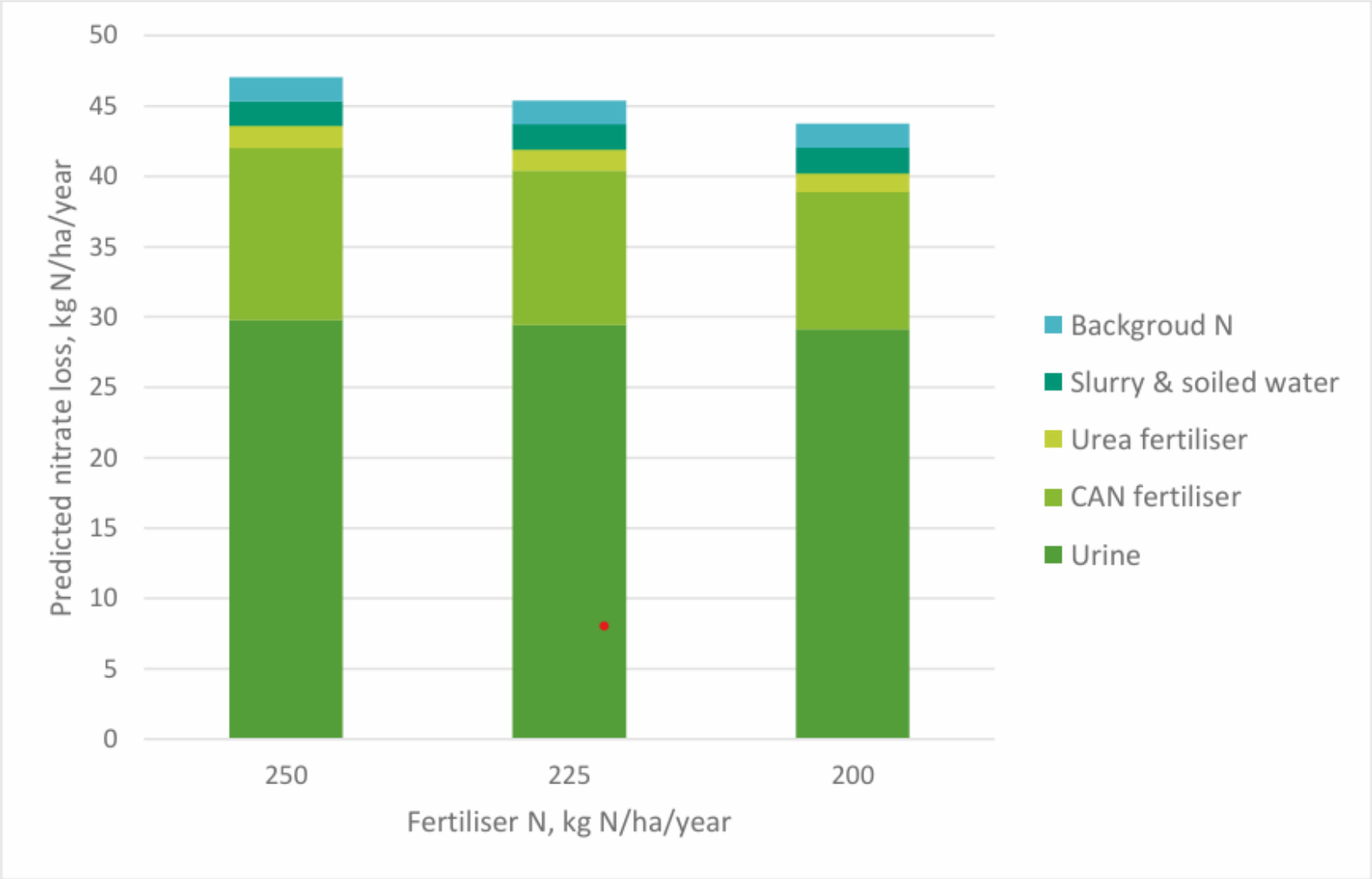



Figure 3.1. The impact of fertiliser N on predicted nitrate losses from a well-drained spring-calving grass-based dairy farm operated at a stocking rate of 250 kg organic N/ha.

Sources of nitrate loss

Urine patch:
200–1,000 kg Nitrogen/ha



The Nitrogen Cycle

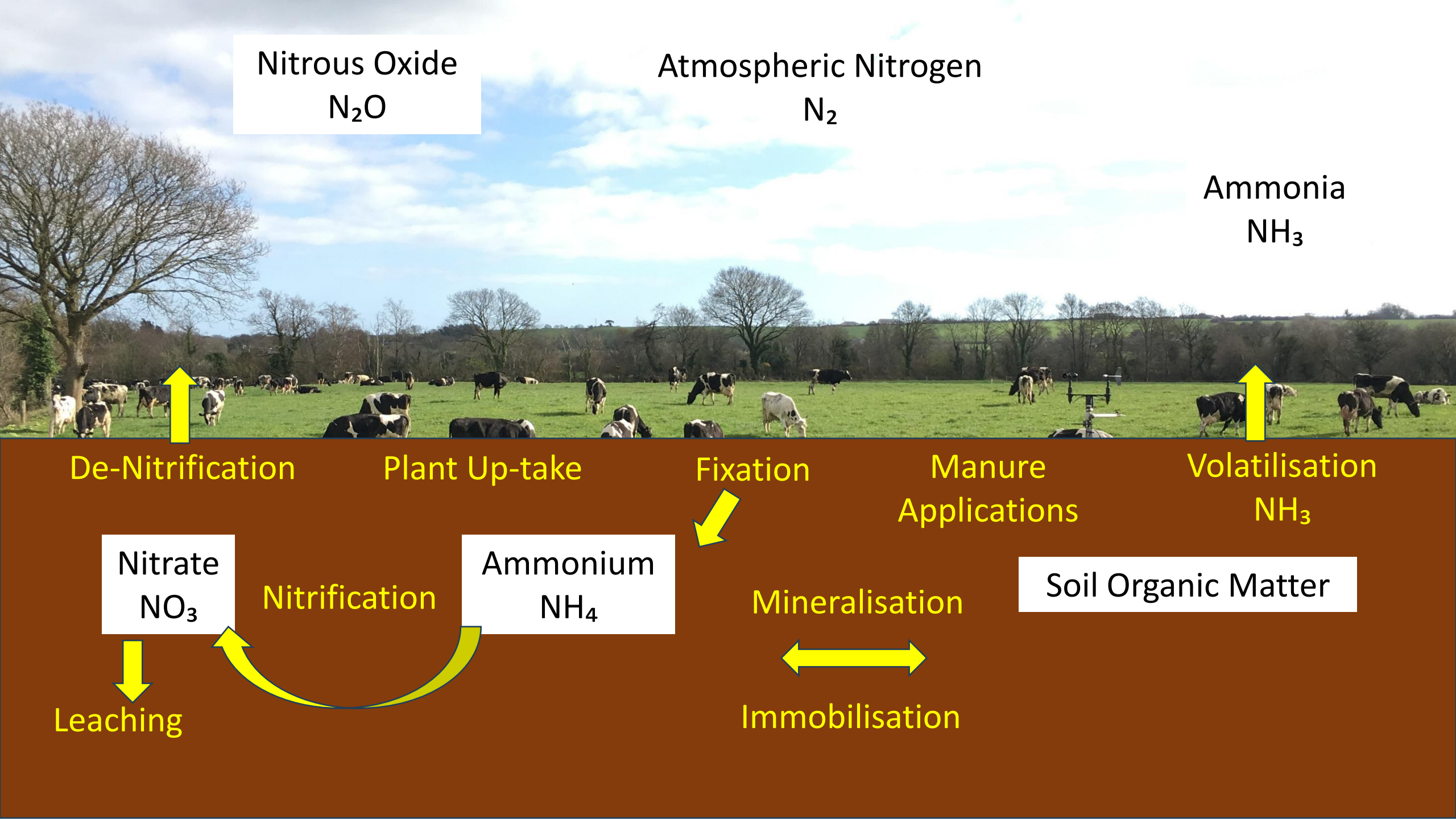


Nitrate
NO_3

Ammonium
NH_4

Soil Organic Matter


Atmospheric Nitrogen
N_2
Fixation
Manure Applications
Nitrate NO_3
Nitrification
Ammonium NH_4
Mineralisation
Soil Organic Matter


Nitrous Oxide
N_2O
Atmospheric Nitrogen
N_2
Ammonia
NH_3
De-Nitrification
Plant Up-take
Fixation
Manure Applications
Volatilisation
NH_3
Nitrate
NO_3
Nitrification
Ammonium
NH_4
Mineralisation
Soil Organic Matter
Leaching
Immobilisation

What do we need to do to minimise N loss ?

- There is no “silver bullet”
- A good understanding of the Nitrogen Cycle
- Do not ignore the influence of the landscape - hydromorphology
- Timing of actions are critical
- Target “hot spots” – scale of mitigation action implementation

Regulation alone can not achieve this!