



NITROGEN

Interactions between Soil and Water

Karl Richards

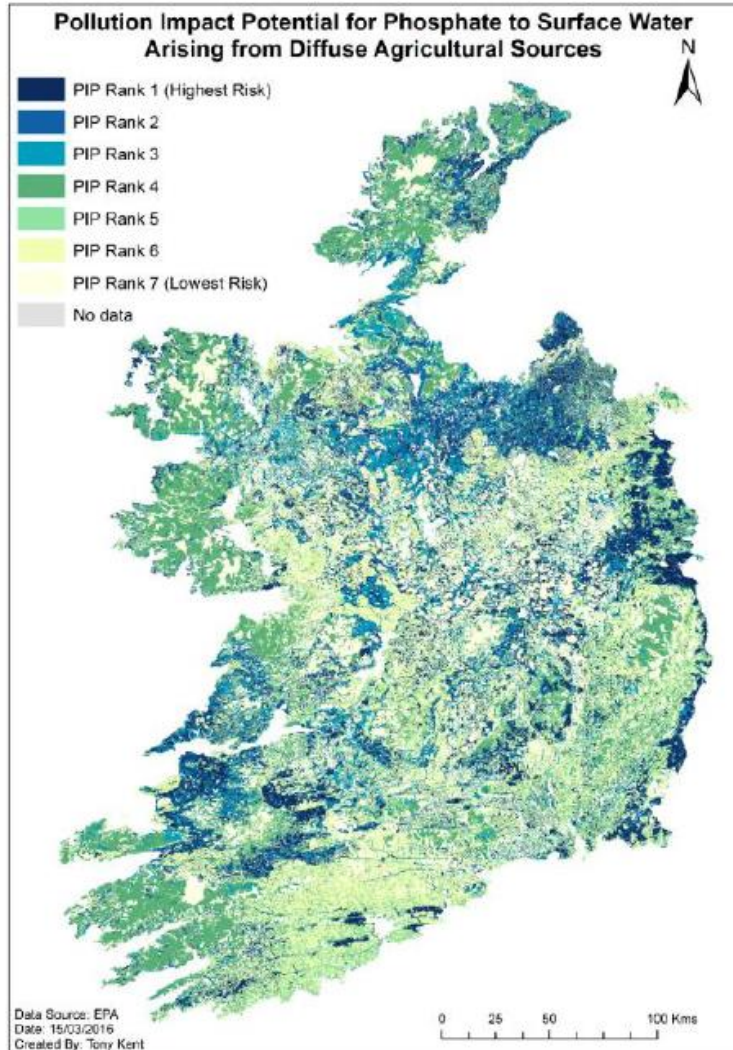
Head of Environment Soils and Land Use Dept.

Crops Environment & Land-Use Programme



Reminder from last weeks webinar

Critical source areas – risk of nutrient losses from diffuse agriculture



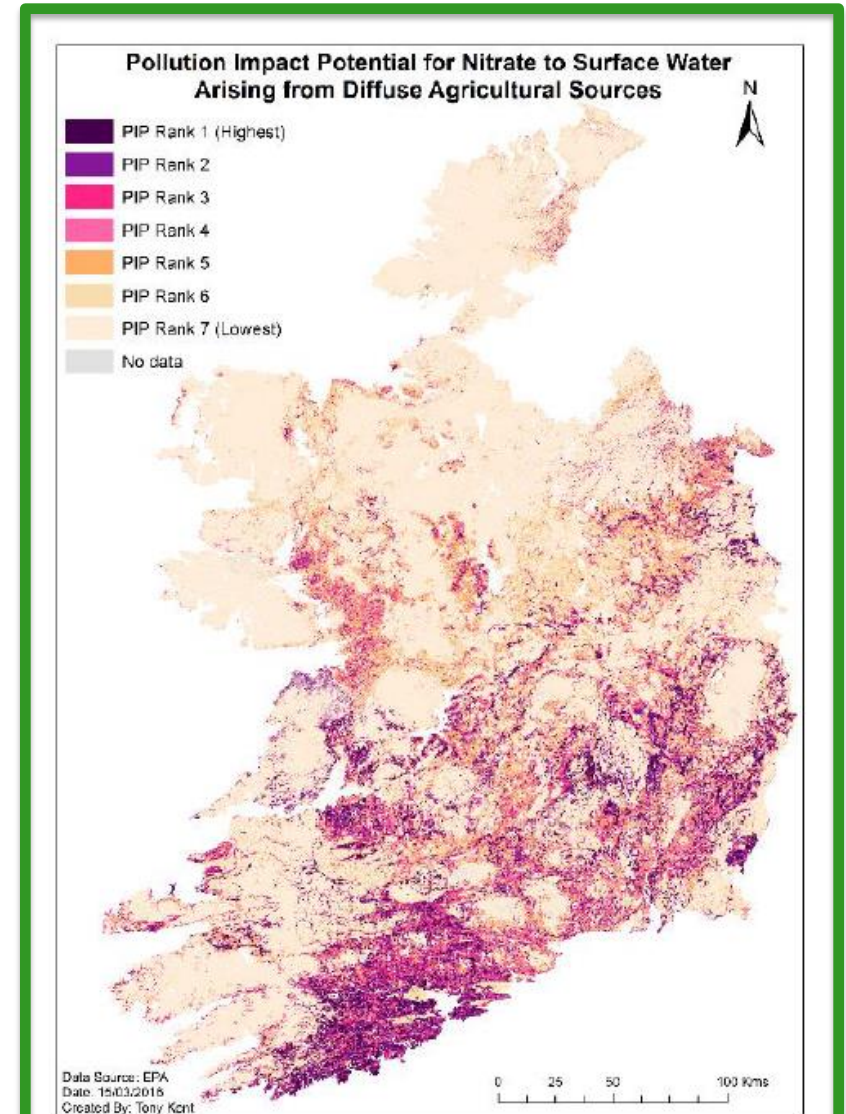
Phosphorus



Nitrate

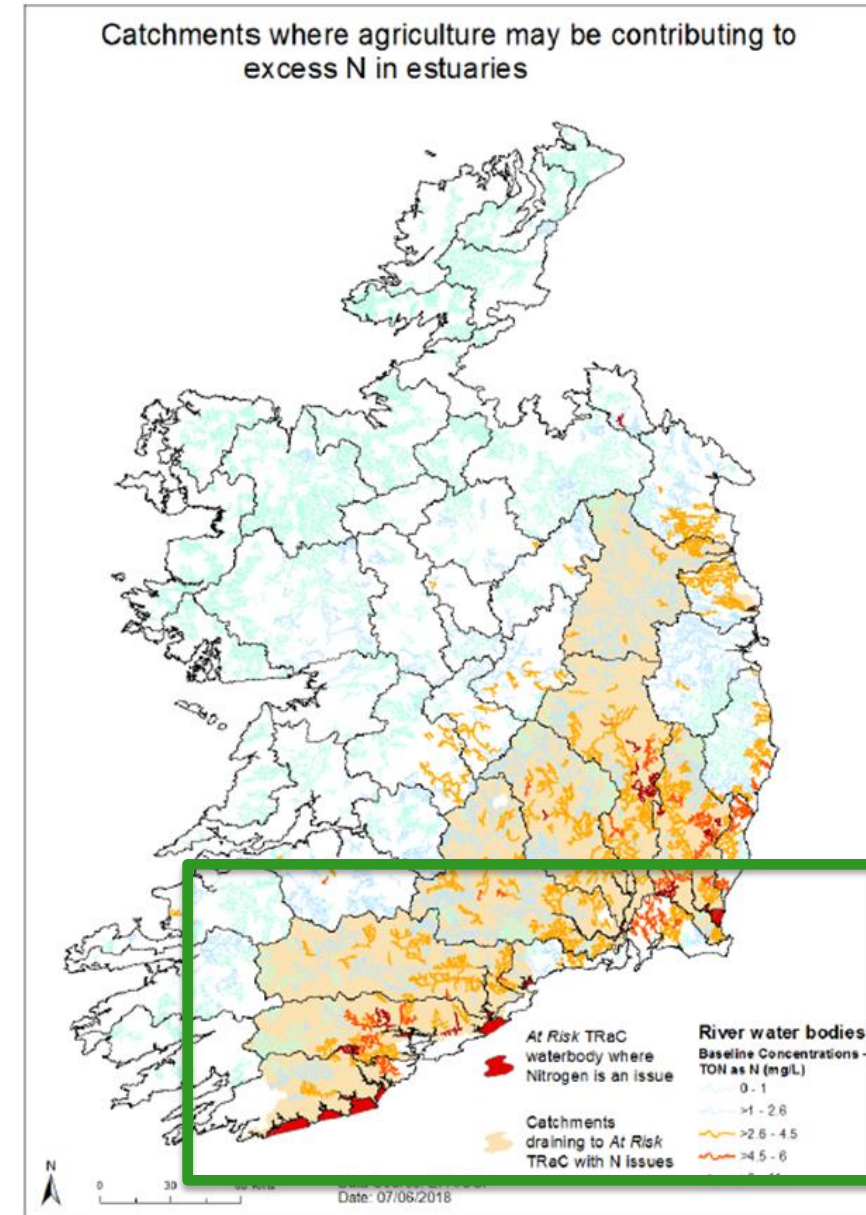
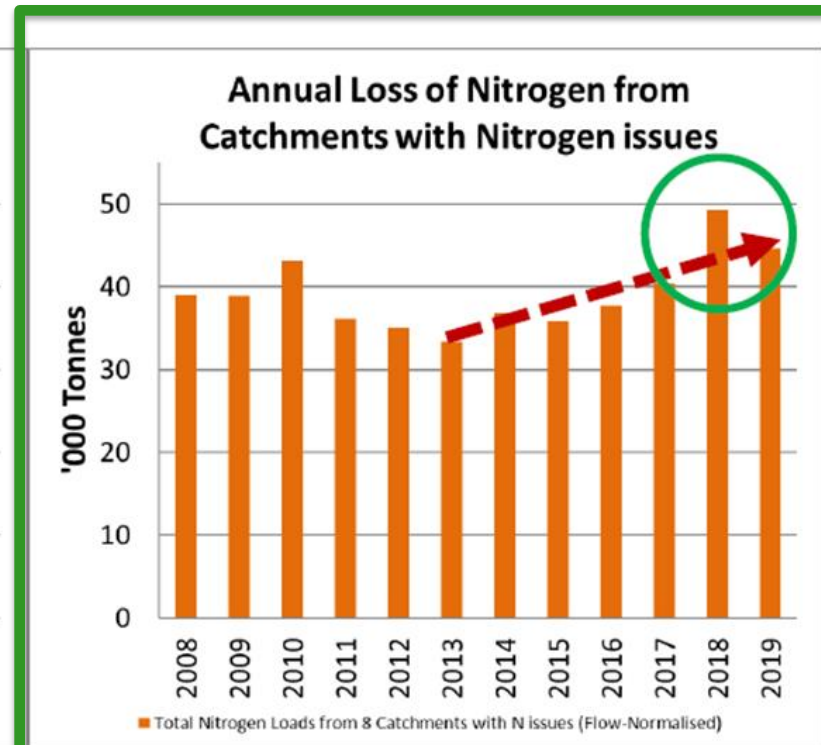
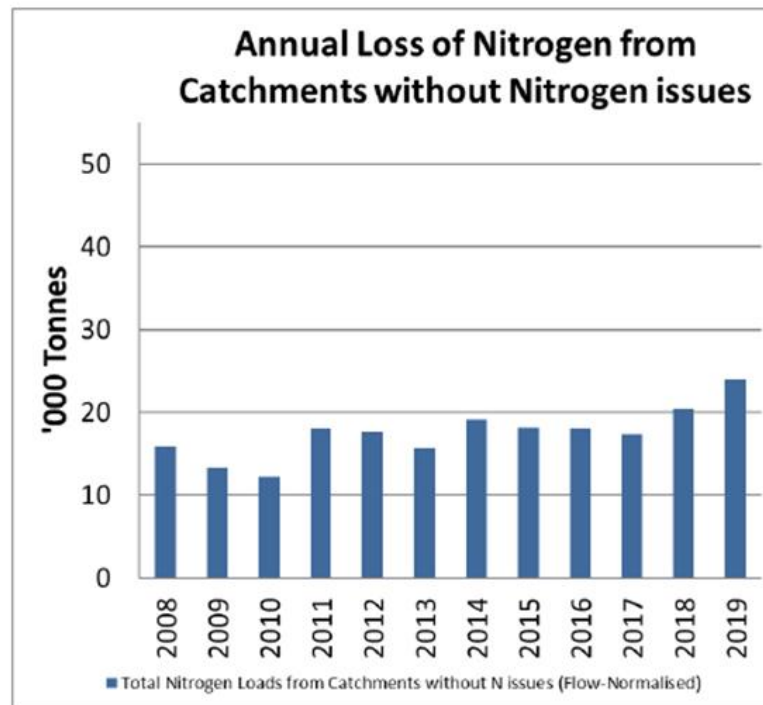


Load + susceptibility
2012 DAFM data –
currently being
updated



Regional agricultural nitrogen issues

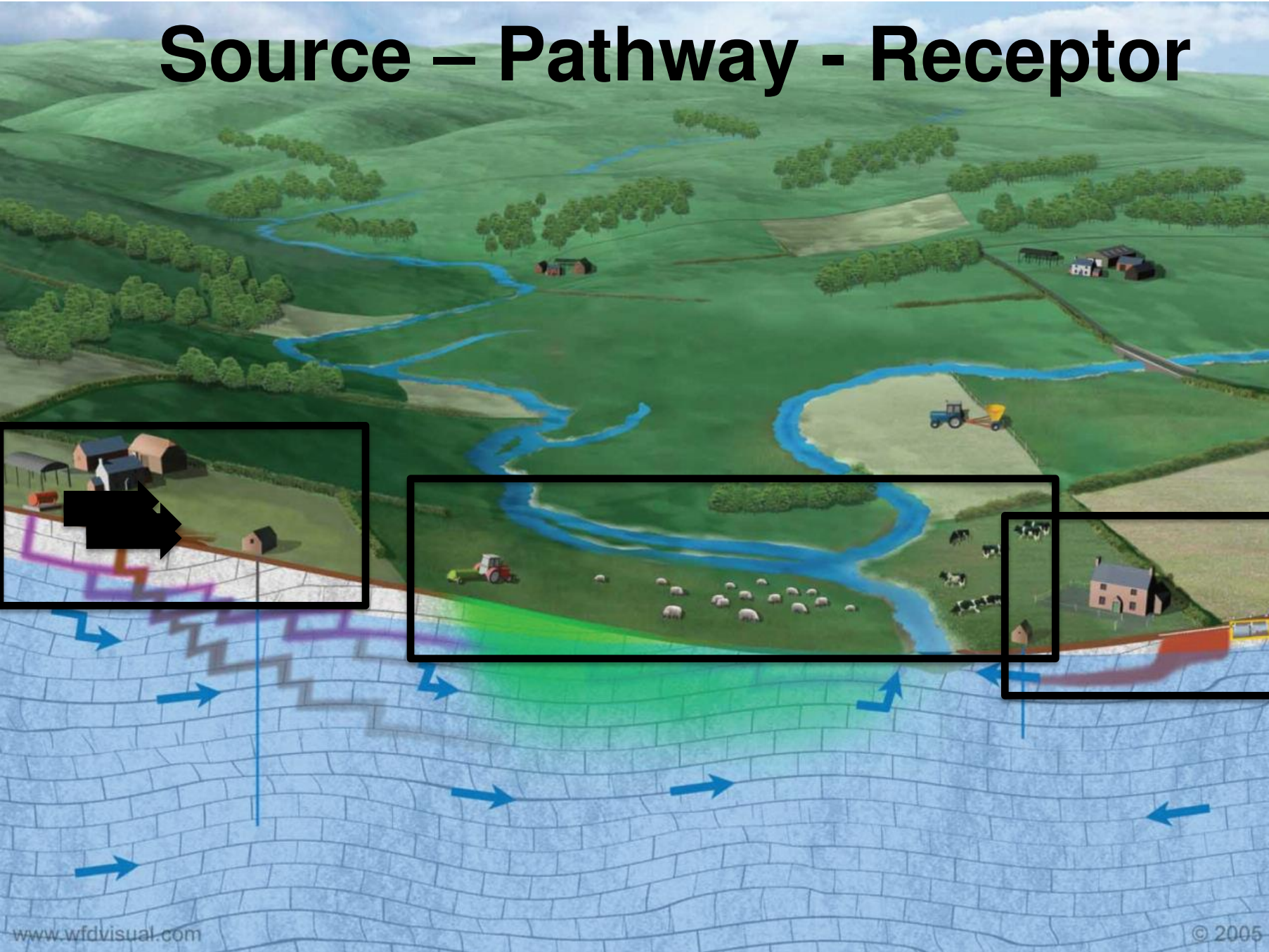
- In the freely draining catchments in the south east, nitrogen losses continue to rise, and are over double the annual losses from the west.
- Agriculture is the main source.
- Spike in losses in 2018 in a drought year. 2020?



Reminder from last weeks webinar

- Nitrate issue regional increasing from NW to SE
- Free draining catchments at risk from Nitrate
- Water quality trends going in the wrong direction
- So what contributes to nitrate loss to water

Source – Pathway - Receptor



- **Sources**
 - Fertiliser/manure
 - Grazing returns
 - Fallow land
- **Pathways**
 - Underground
 - Overground
 - Combined
- **Targets**
 - Groundwater
 - Surface water
 - Wetlands
 - Estuaries
 - Coastal waters

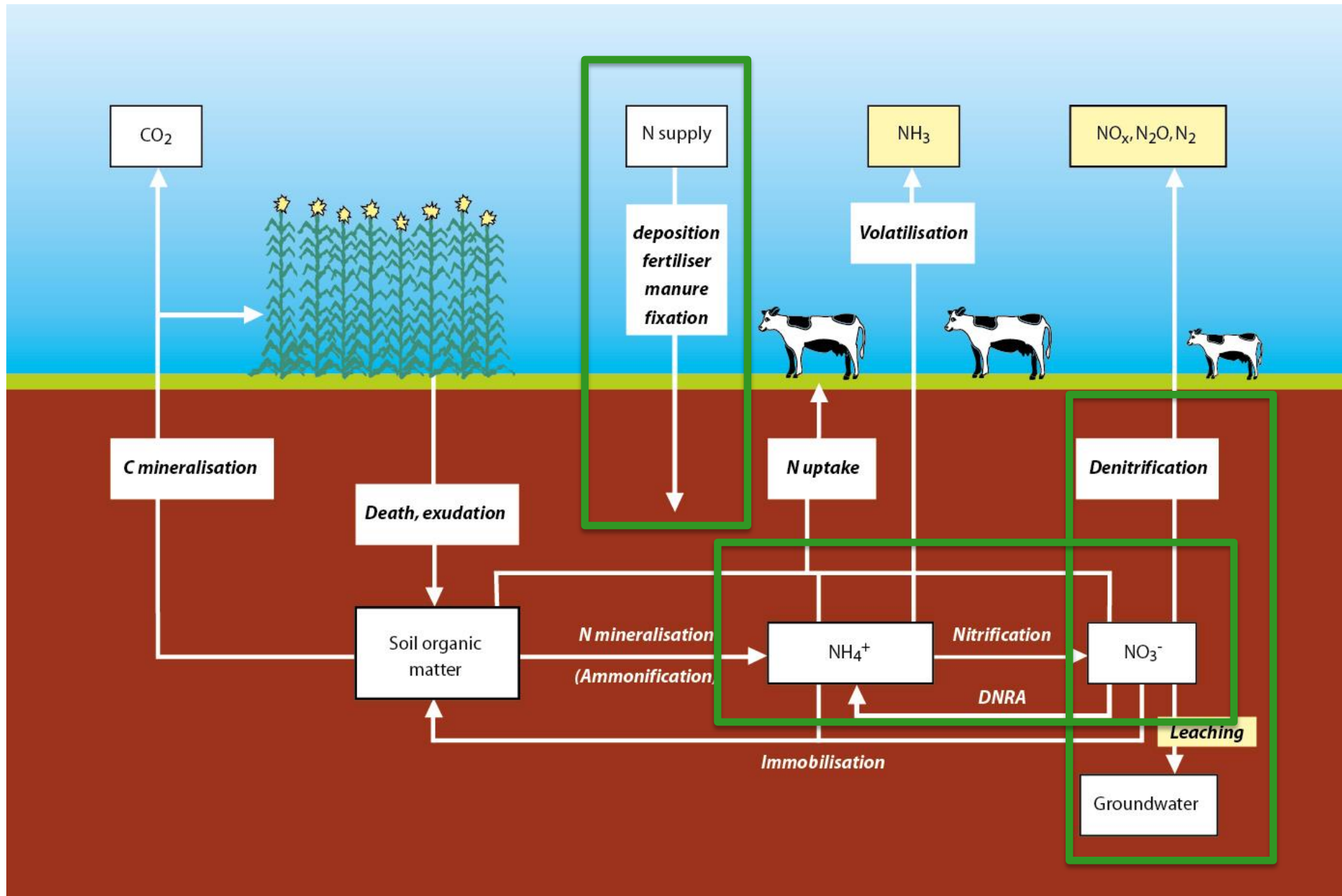
The Perfect Recipe: Nitrate Leaching

In order to have nitrate leaching
you must have:

- Nitrate in the soil
- Have water percolating through the soil profile



Overview of the Nitrogen Cycle



How much Nitrate is acceptable?

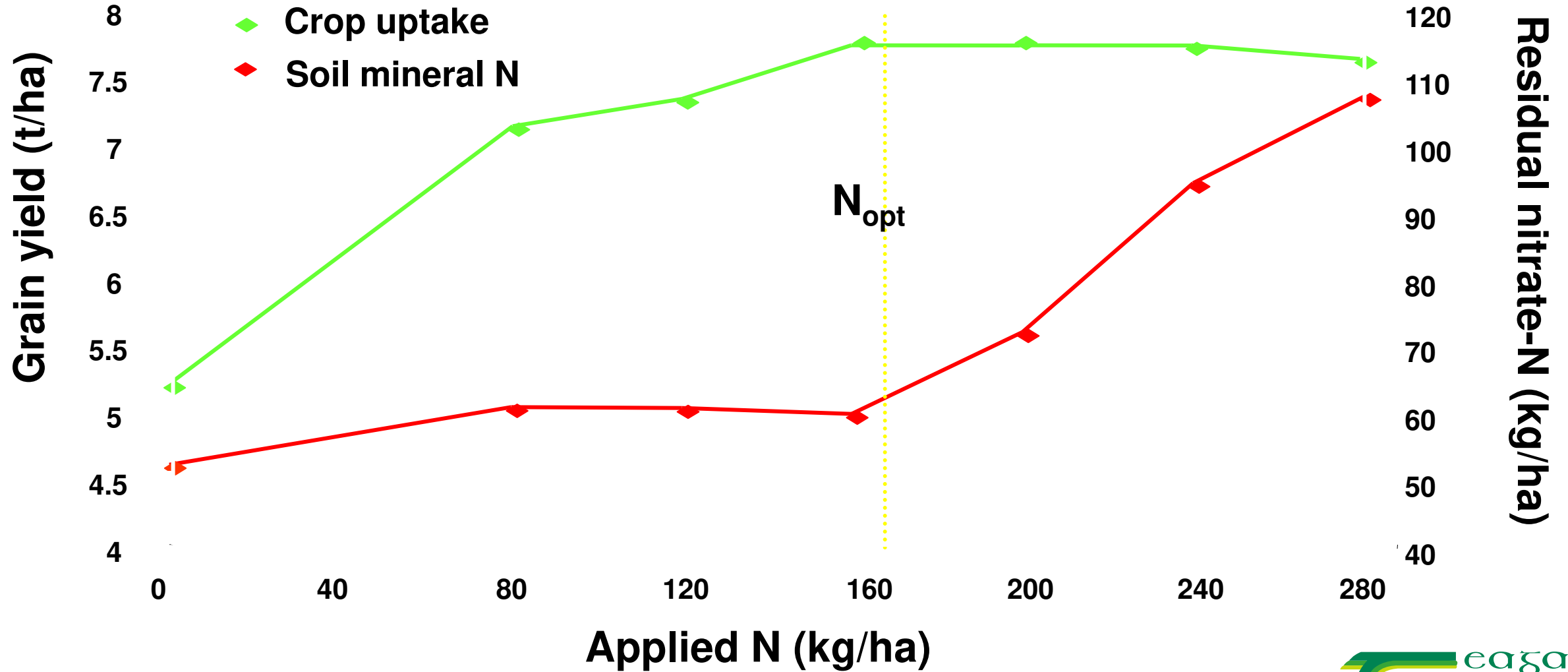
- To protect freshwater ecology
 - 1.8mg/L N
 - 0.06 mg/L $\text{NH}_4\text{-N}$ as N
 - 0.035 mg/L P as P
- To protect estuaries and coasts
 - 2.6 mg/L DIN as N
- To protect drinking water
 - Mean 8.5 mg/L $\text{NO}_3\text{-N}$ (37.5 mg/l NO_3)
 - Maximum 11.3 mg/L $\text{NO}_3\text{-N}$ (50 mg/L NO_3)



Source - What factors influence Nitrate in soil

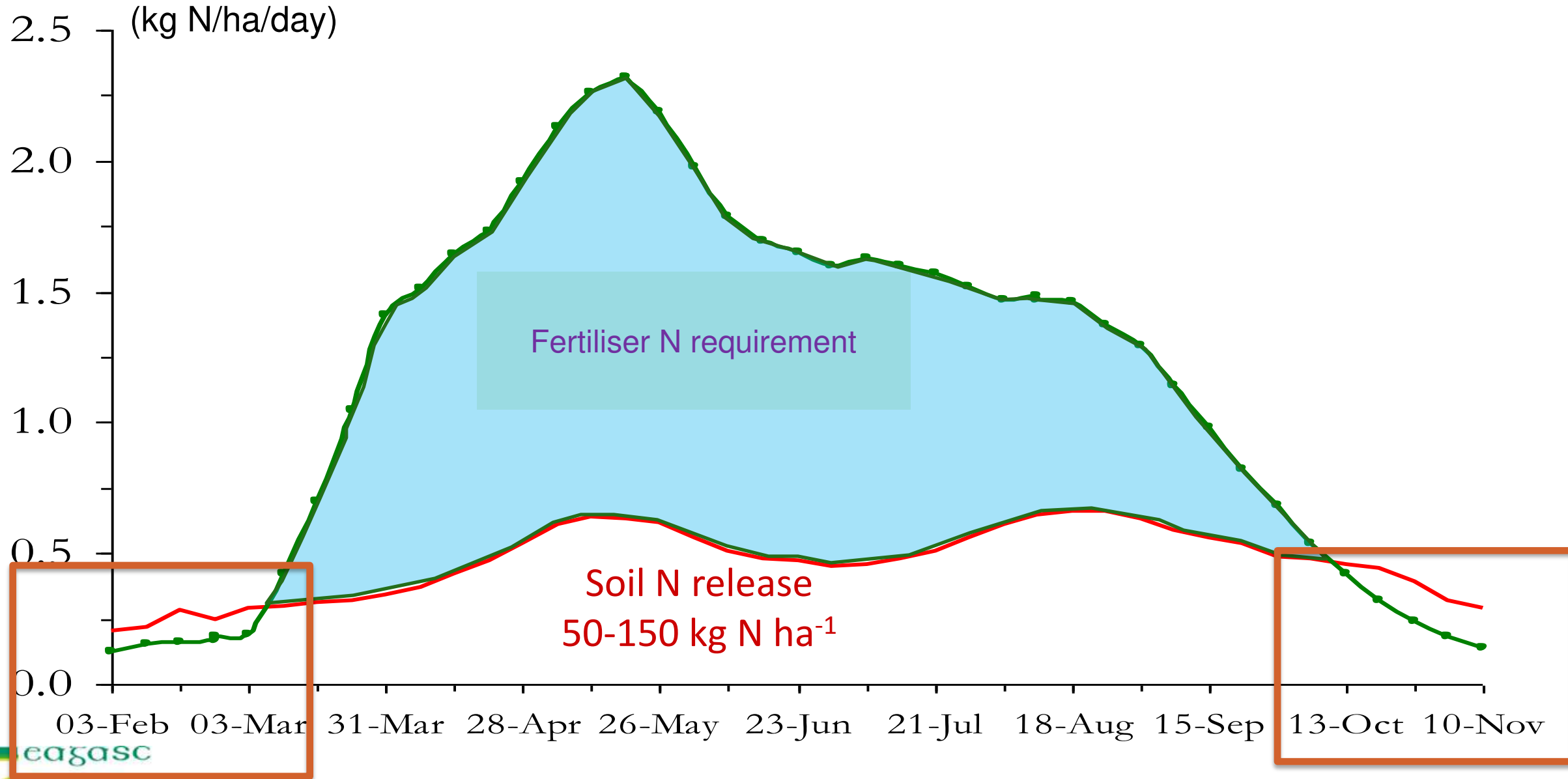
- Fertiliser/manure application rate
- Application timing (e.g. winter v spring)
- Soil nutrient status
- Crop type
- Overwinter crop cover

Fertiliser application rate



Source: Chaney (1990) J. Ag. Sci., Camb. 114:171-176

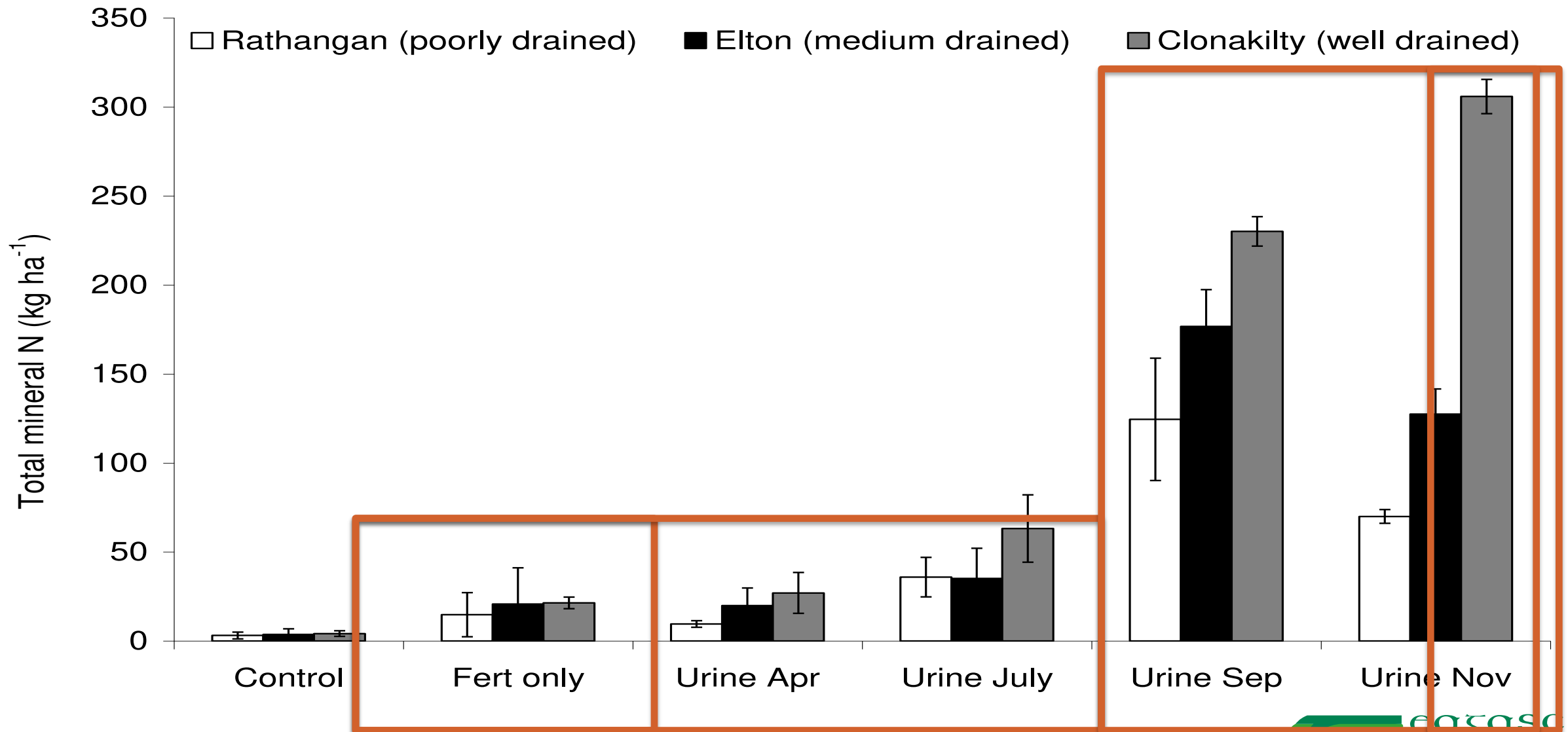
Nitrogen Application Timing



Effect of grazing on nitrate leaching

- Urine patches associated with high N loss
- N load in patch up to 1000 kg/ha
 - Ireland N load 300-500 kg/ha
- Limited potential up take
- Urinations in autumn increase risk N leaching
- Measures to reduce losses
 - Reduce:- N conc., no. patches
 - Timing, inhibitors

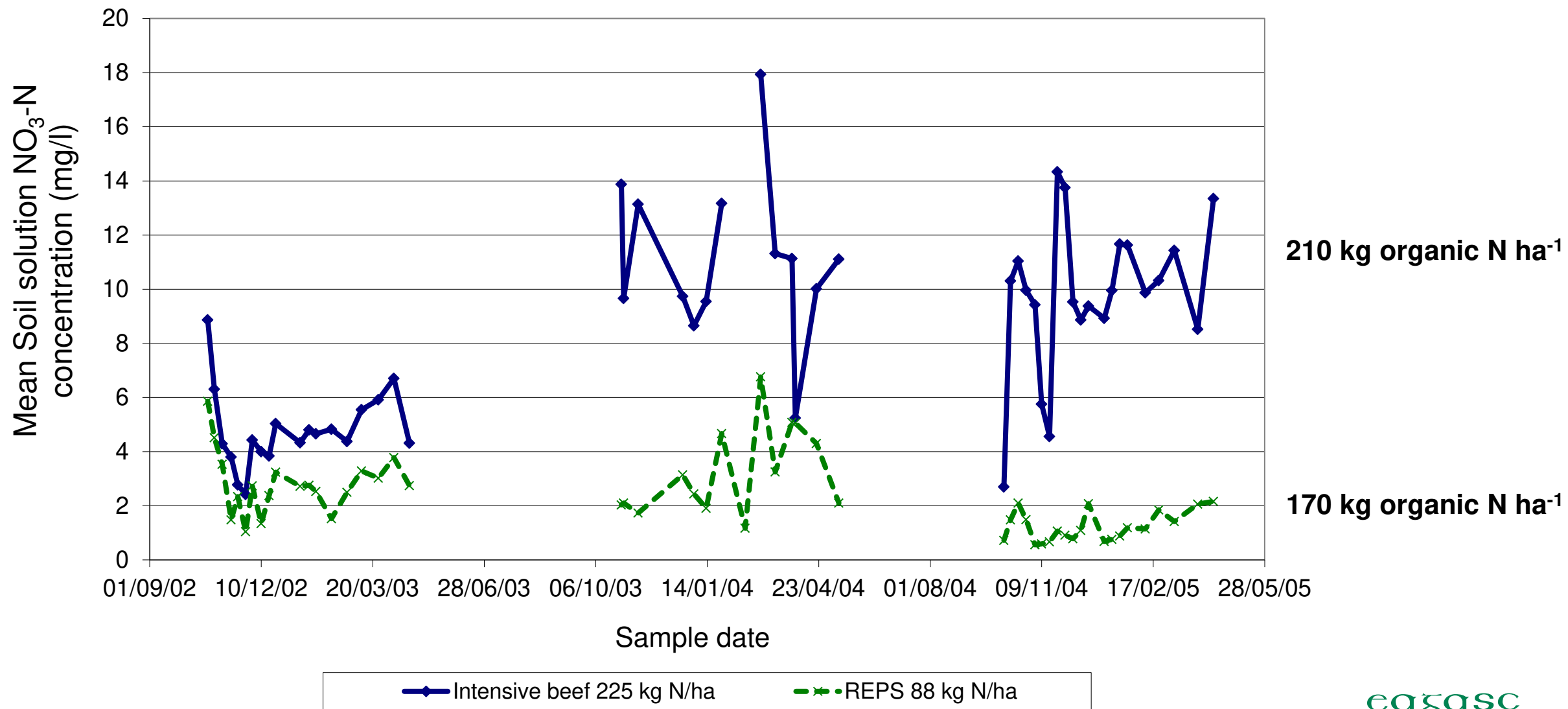
Urine timing and NO₃-N leaching



Richards *et al.* 2005; Hoekstra *et al.* 2020

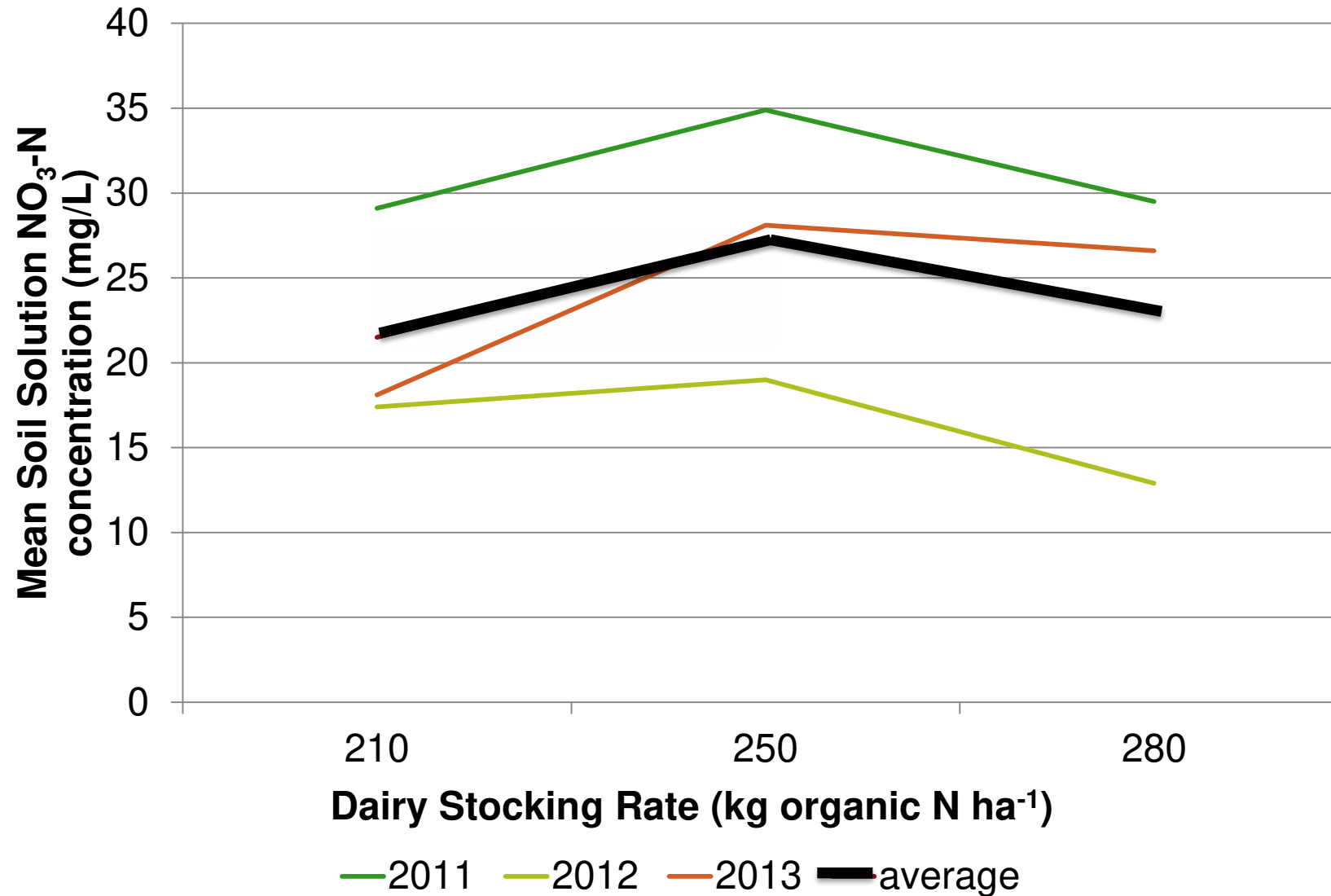
Stocking Rate v NO₃-N leaching

Beef Systems: 210 v 170 kg organic N ha⁻¹



Stocking Rate – NO₃N leaching

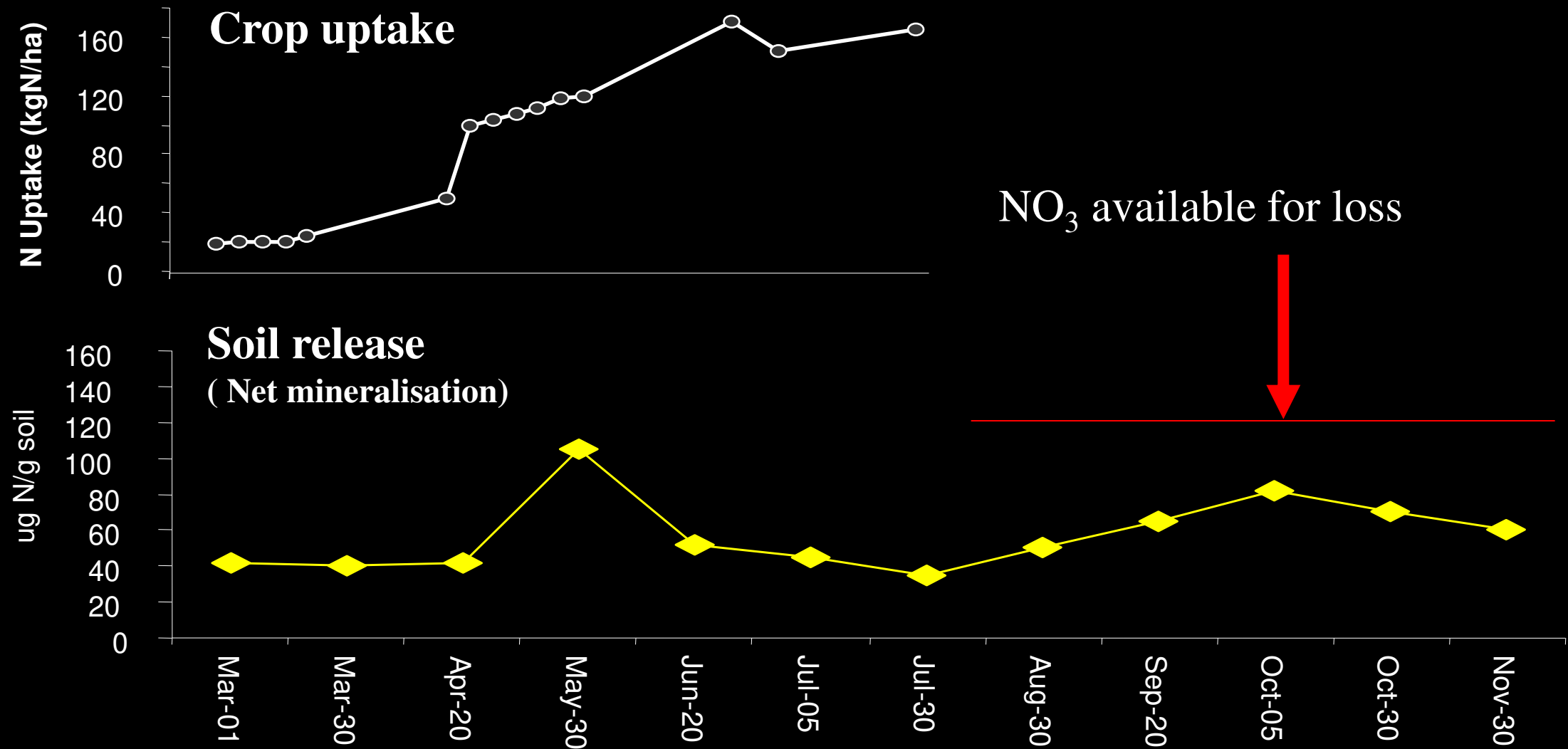
Dairying – 3 years, free draining soil, 1m, 250 kg N ha⁻¹



Crop Type/Soil Type

- Crop type effects uptake of N
- Grassland has long growing season (250-330)
- Spring crops have short growing period
- Winter crops ability for autumn uptake

Spring Cropping System

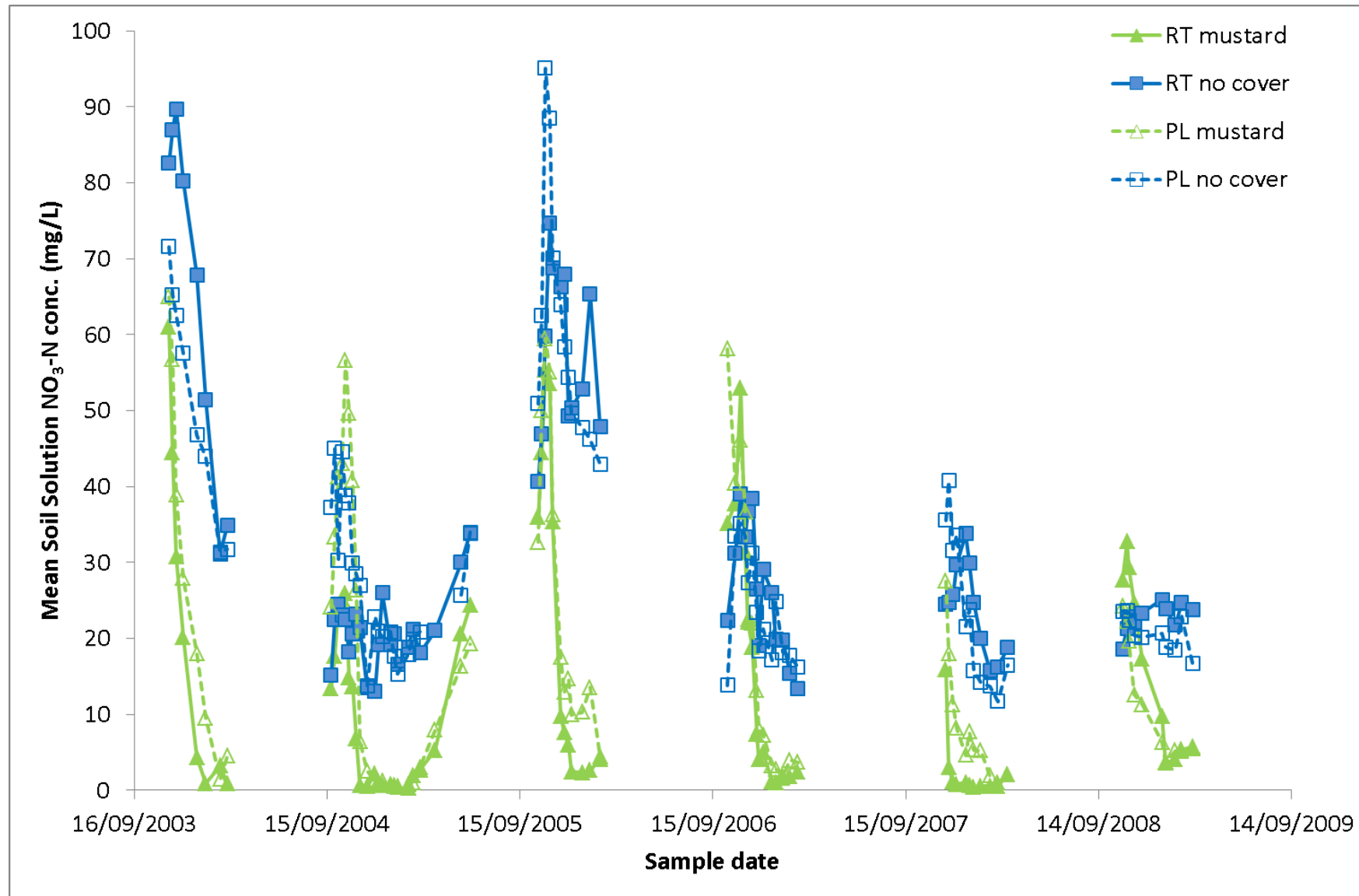


Mustard Cover Crop

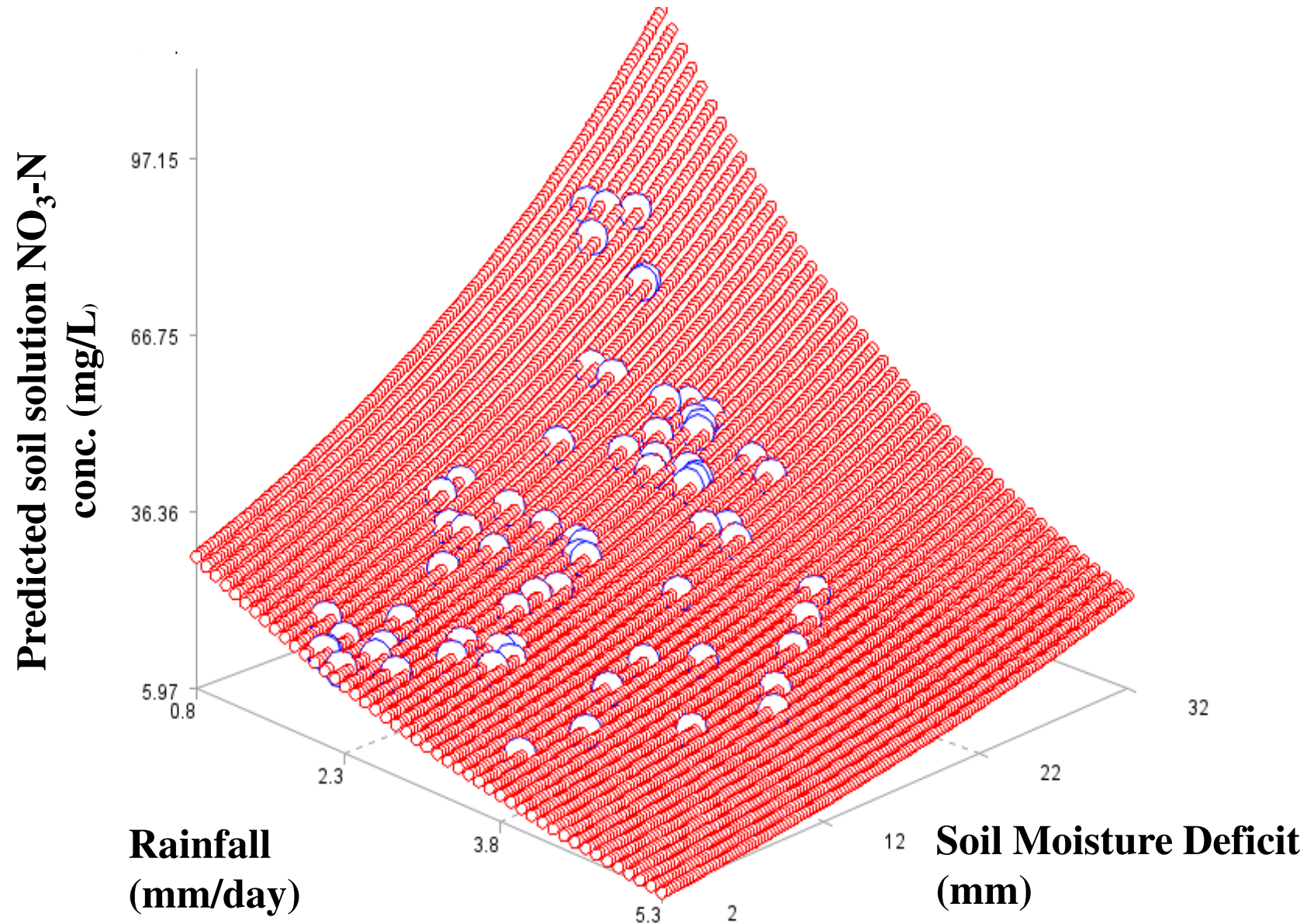
Teagasc, Oak Park



Catch crop - Mustard



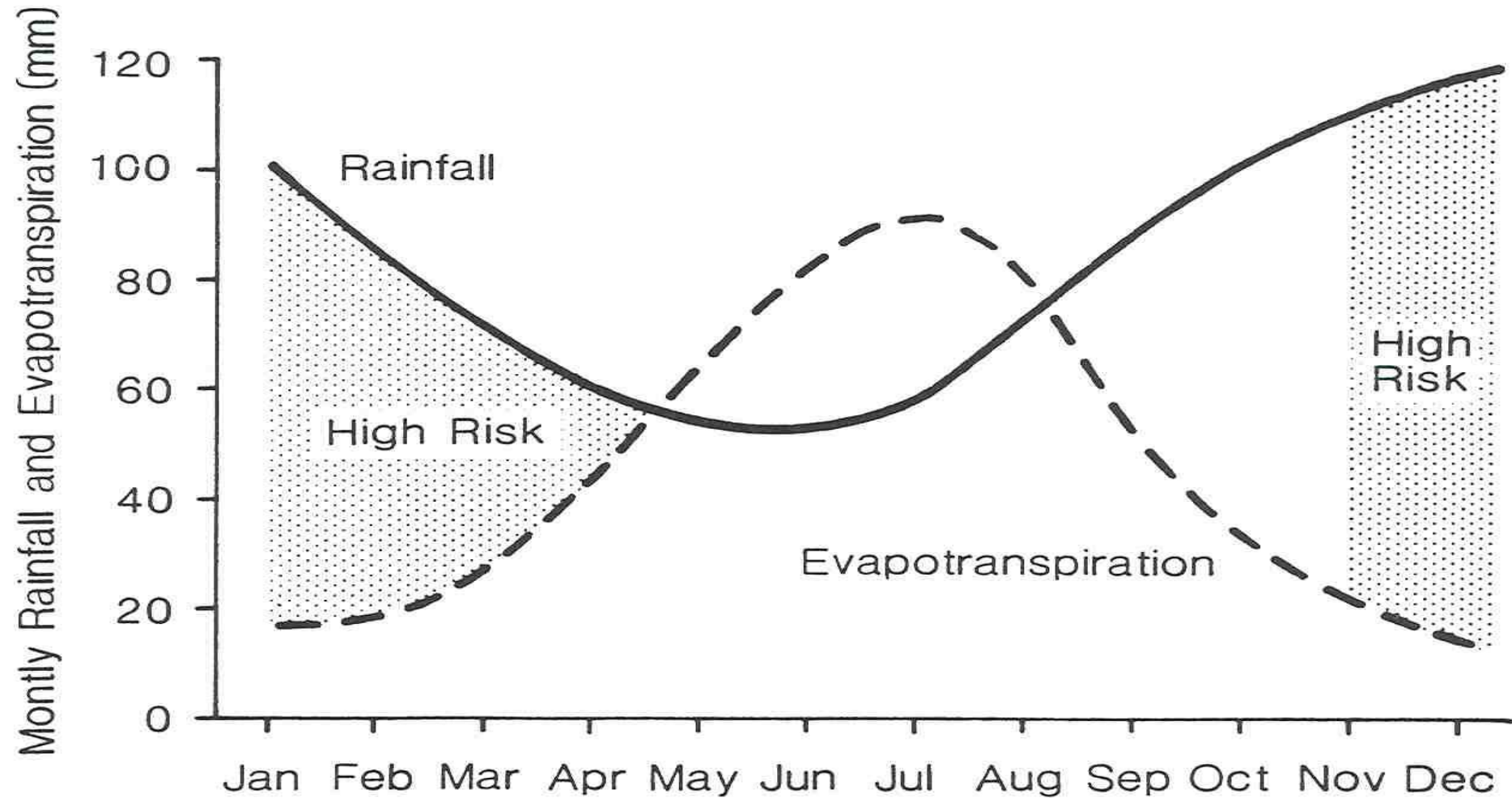
Influence of SMD on $\text{NO}_3\text{-N}$ leaching



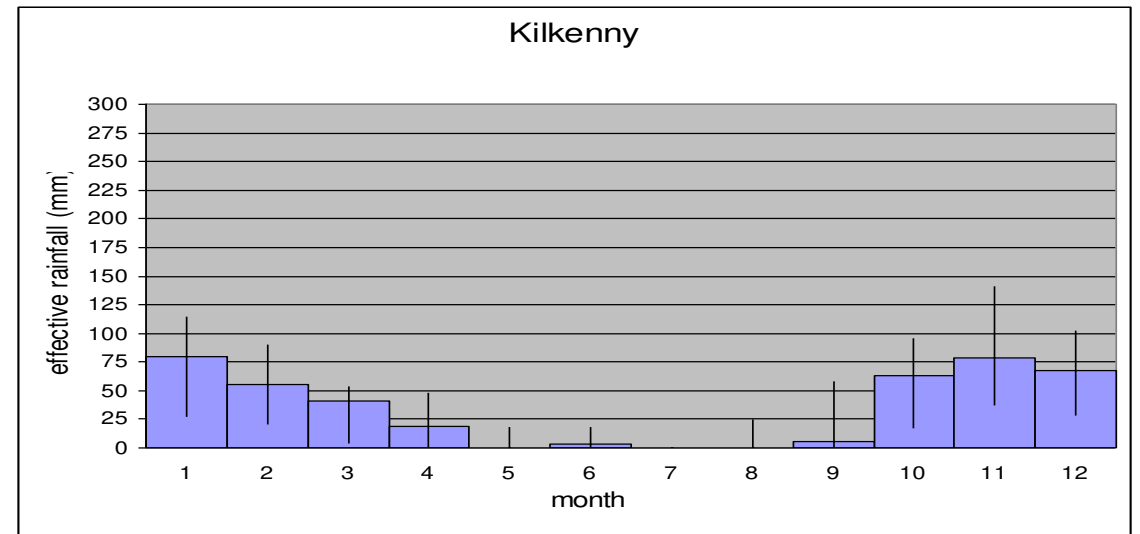
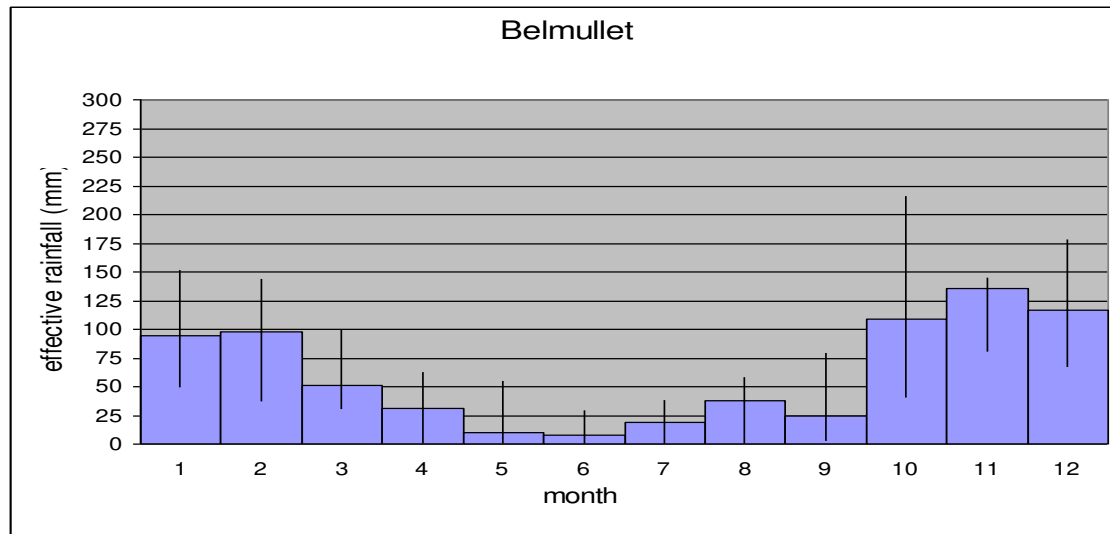
Pathway Factors

- Total rainfall (quantity and distribution)
- Effective rainfall (quantity and distribution)
- Soil type (O_2 status and WHC)
- Depth of soil/subsoil (travel time)
- Depth to water table (O_2 status + drainage)

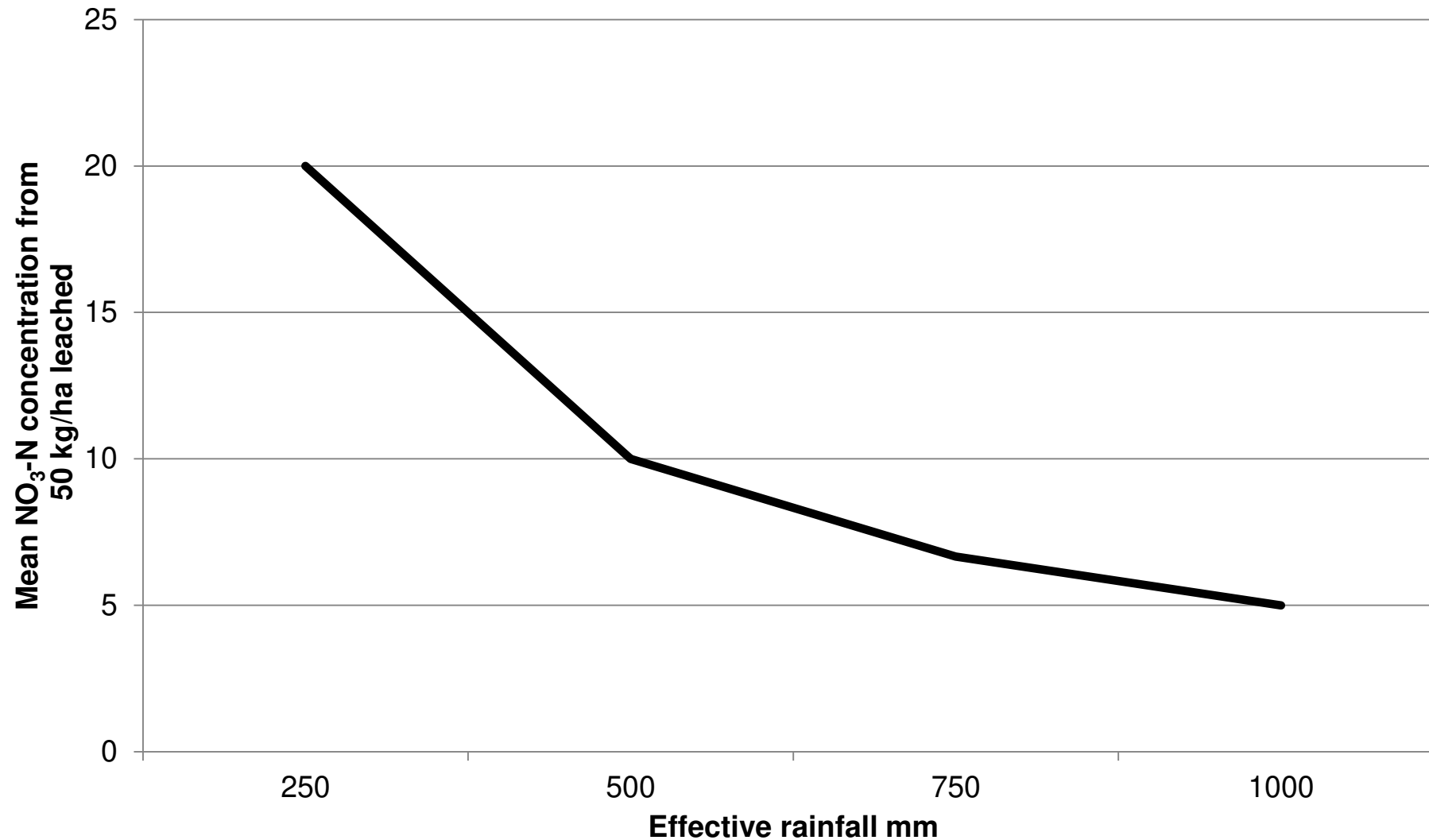
Johnstown Castle water budget



Effective rainfall distribution



Effective rainfall impact on NO₃-N conc



Soil Type

- Soil texture
 - Free draining susceptible to N leaching
 - Poorly drained susceptible to runoff/denitrification
- Water holding capacity (clay>loam>sandy)
- Soil porosity (macropores v mesopores)

Soil Type

Rathangan



Clonakilty



Water Holding Capacity

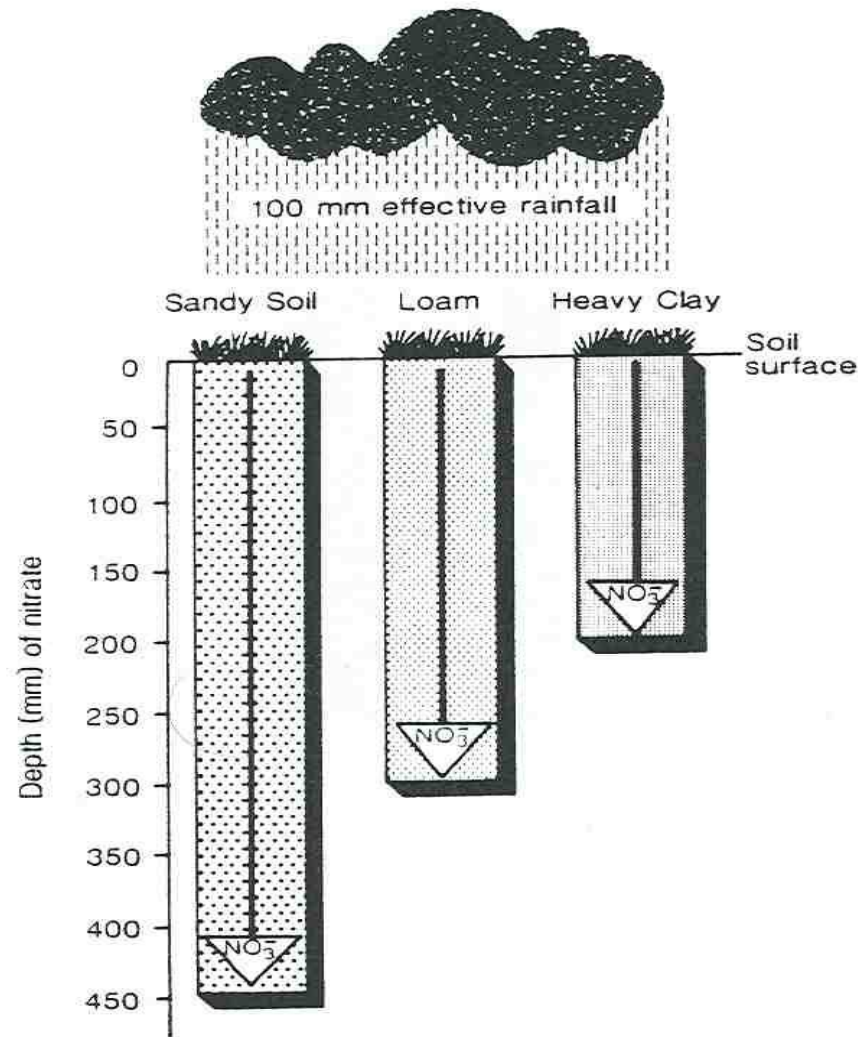


Fig. 9. Approximate depth of nitrate movement with 100 mm effective rainfall (Effective rainfall = rainfall minus evapotranspiration). Nitrate reached depth of almost 450 mm in a sandy soil while on the clay soil it hadn't reached half this depth.

Depth to water table

- Shallow WT:- runoff and denitrification
- Deeper WT:- longer travel times, attenuation
- Artificial drainage increases $\text{NO}_3\text{-N}$ / $\text{NH}_4\text{-N}$ delivery to surface waters
- Wet soils with high water tables can be easily identified (grey = gley soils)

Soil Depth – Travel Time

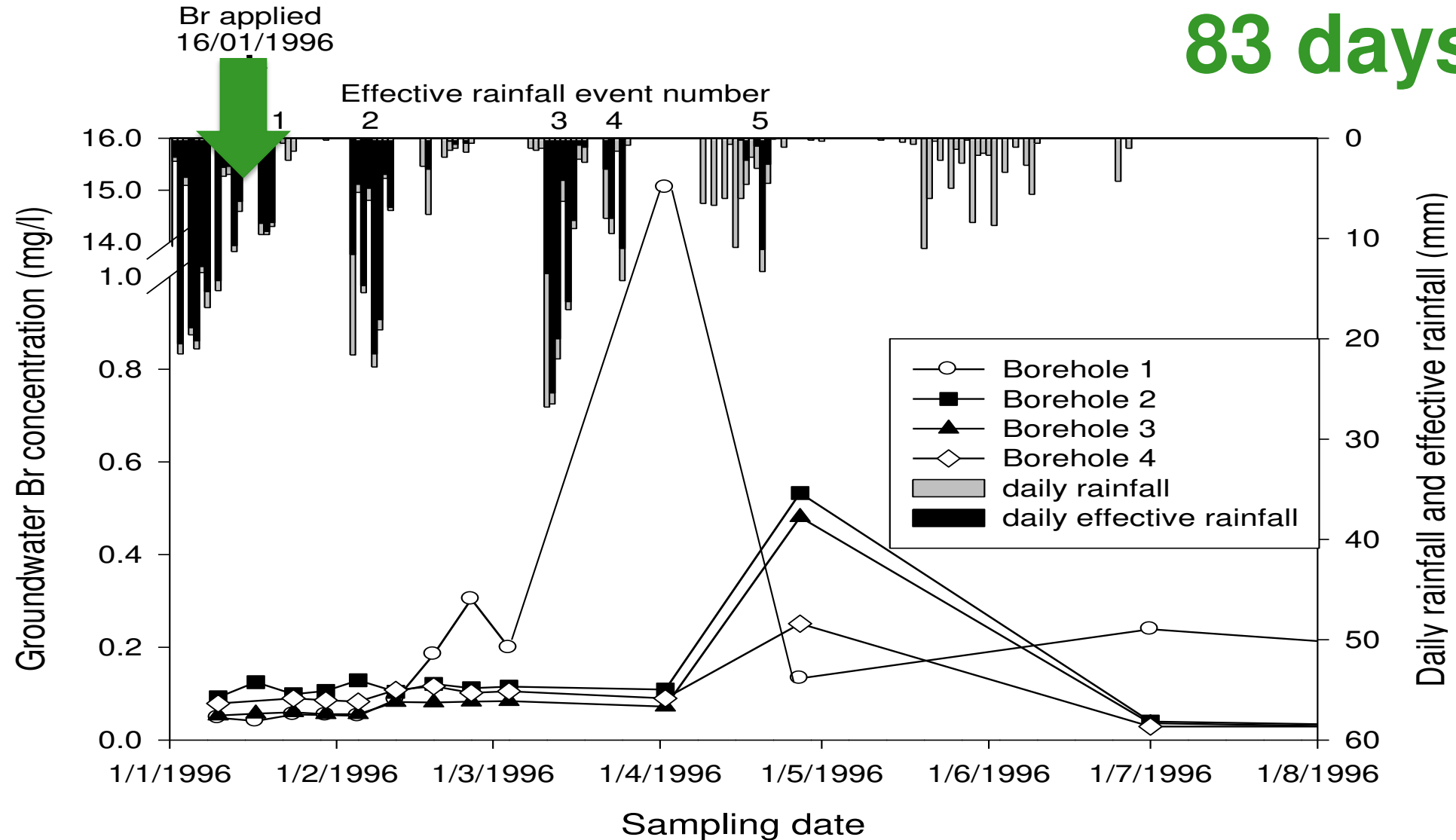


0.7 m b.g.l.

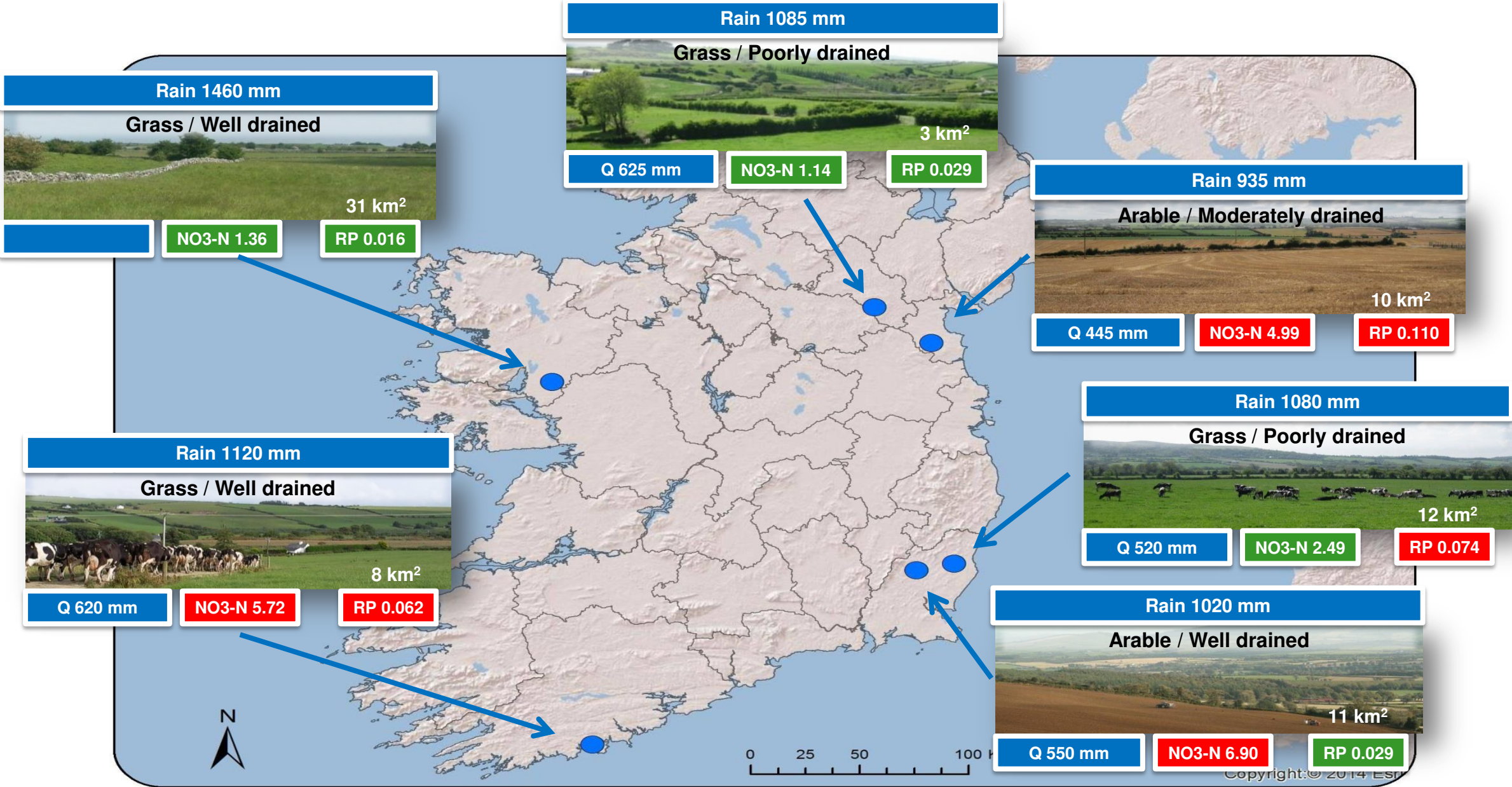
Limestone Bedrock

Travel Time to Groundwater

Travel time
83 days



Catchments: 10-years of water quality monitoring



Summary

■ Source Pressure

- Balance between nutrient supply and crop need
- Avoid autumn/winter applications (rainfall > evapotranspiration)
- Dirty water care needed (NMP)
- Ploughing of grassland (timing: spring < autumn)
- Over winter cover important to reduce N leaching

■ Pathway

- Timing of leaching varies nationally
- Anaerobic conditions lead to denitrification
- <WHC increased depth of leaching
- Catchment hydrology:- >baseflow N loss

