NITROGEN
Interactions between Soil and Water

Karl Richards

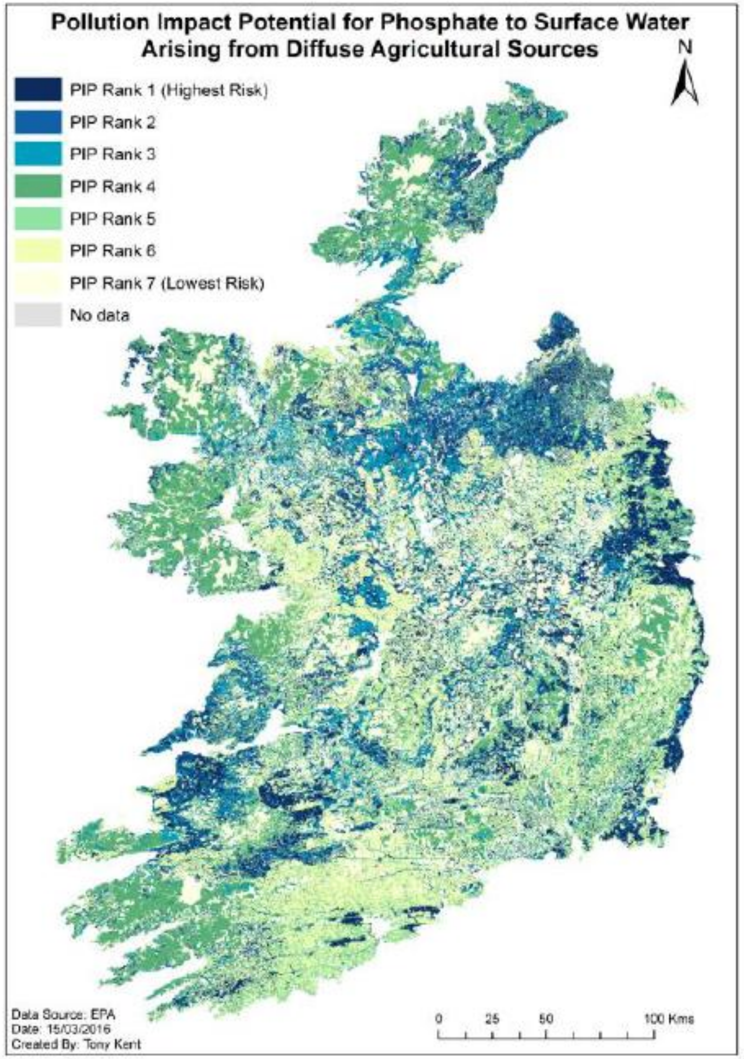
Head of Environment Soils and Land Use Dept.

Crops Environment & Land-Use Programme

Teagasc
Agriculture and Food Development Authority

Reminder from last weeks webinar

Critical source areas – risk of nutrient losses from diffuse agriculture

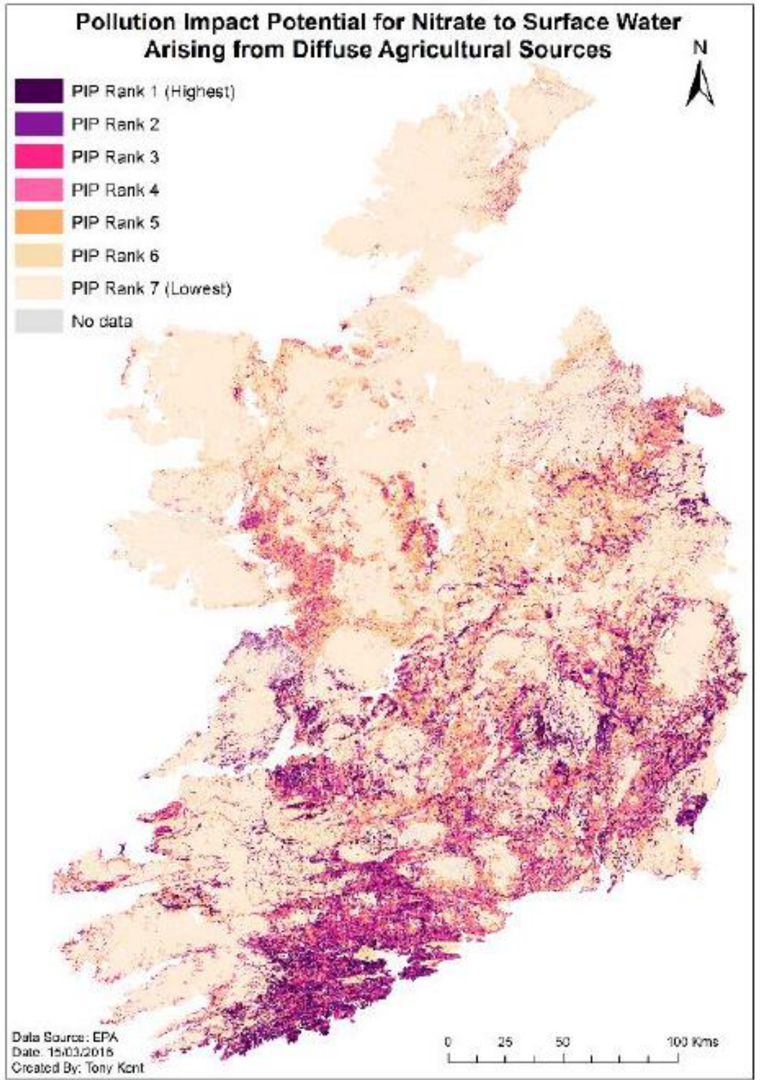


Phosphorus

Nitrate

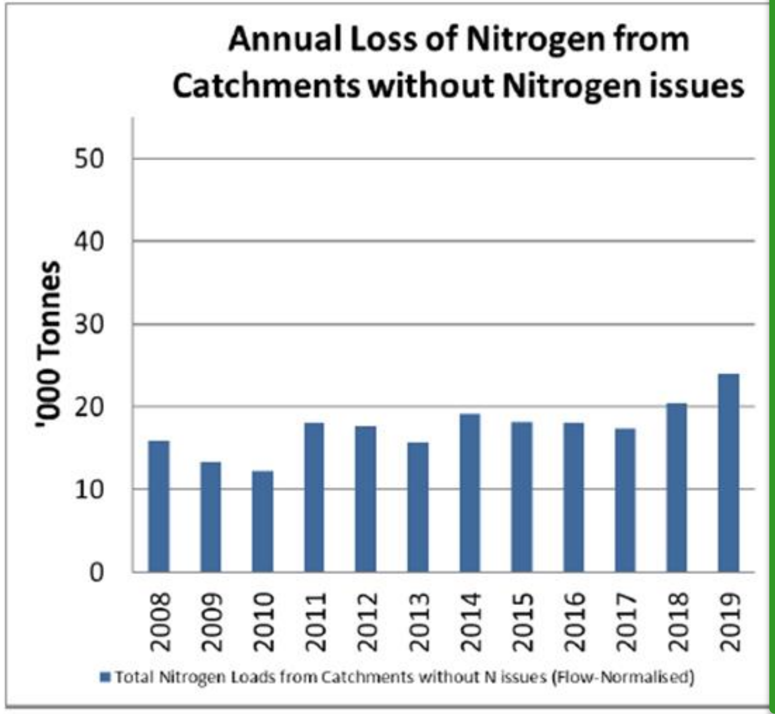
Load + susceptibility

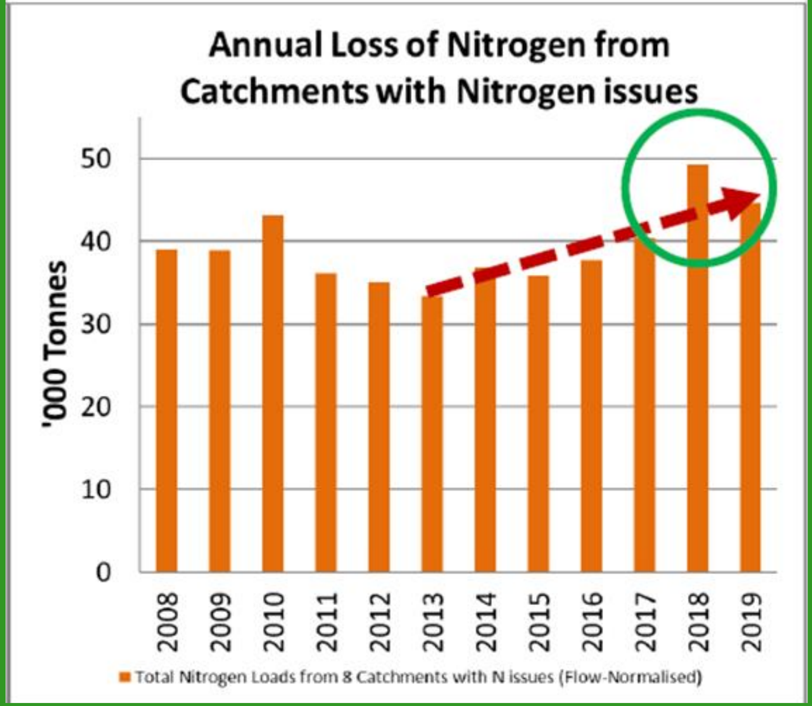
2012 DAFM data – currently being updated

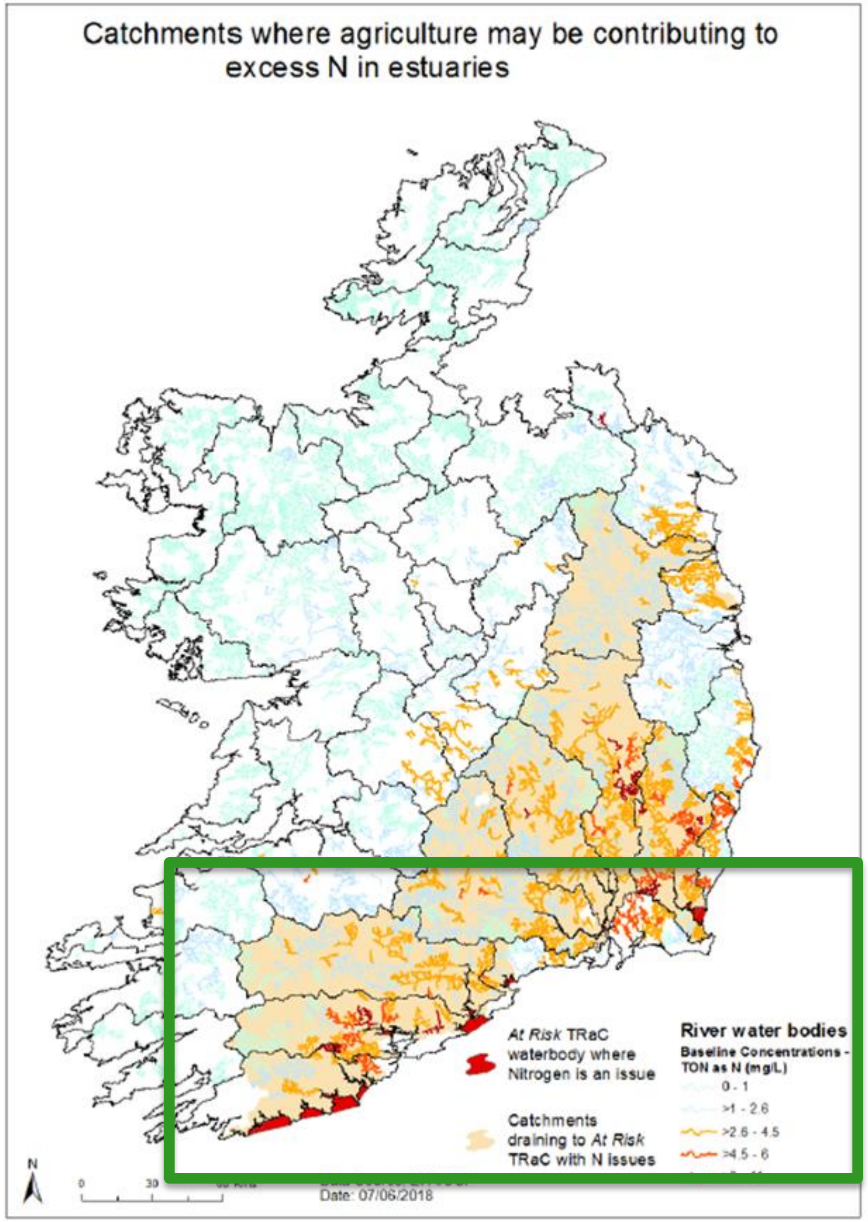


Regional agricultural nitrogen issues

- 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?





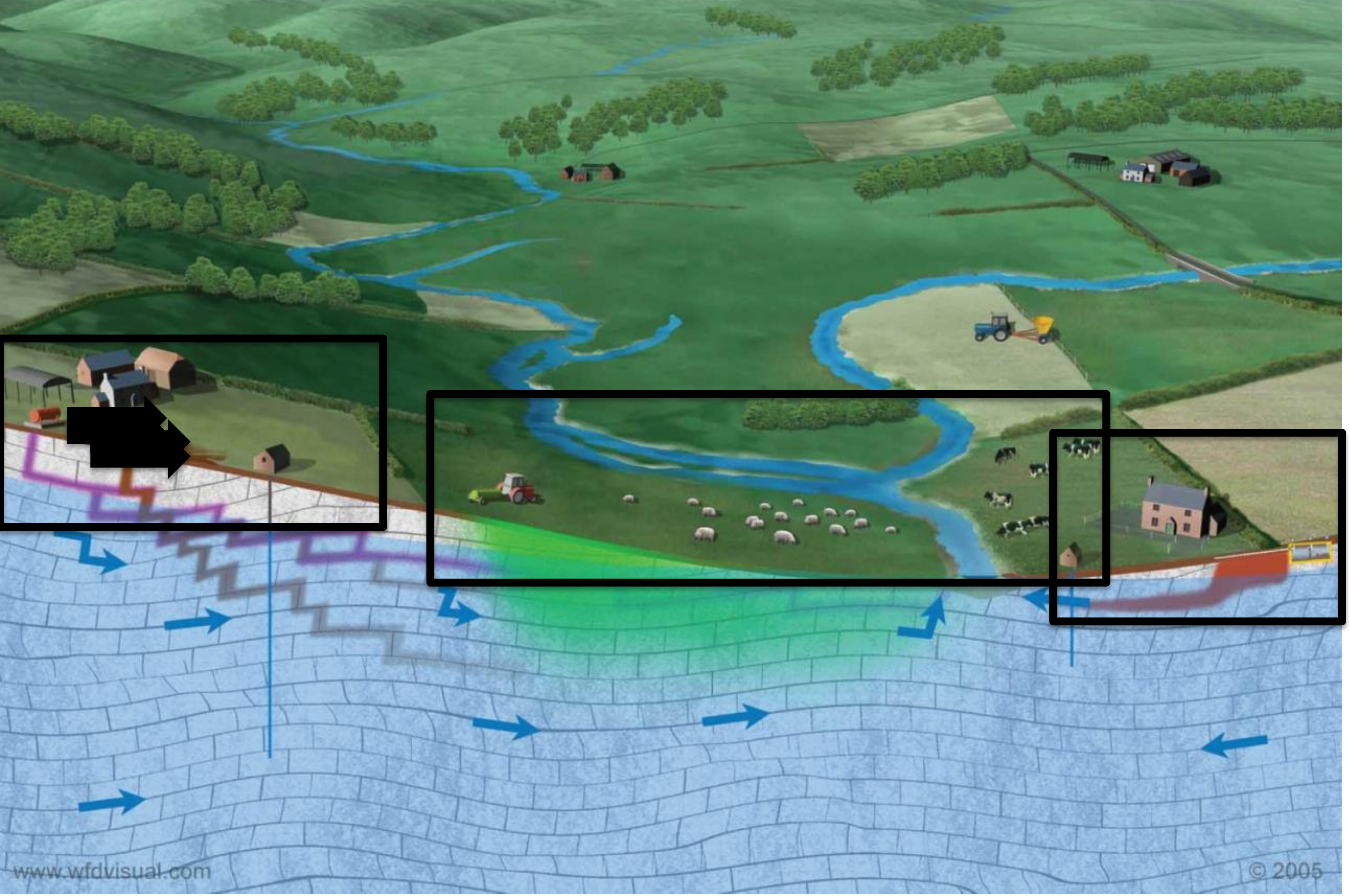


Reminder from last weeks webinar

- 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:

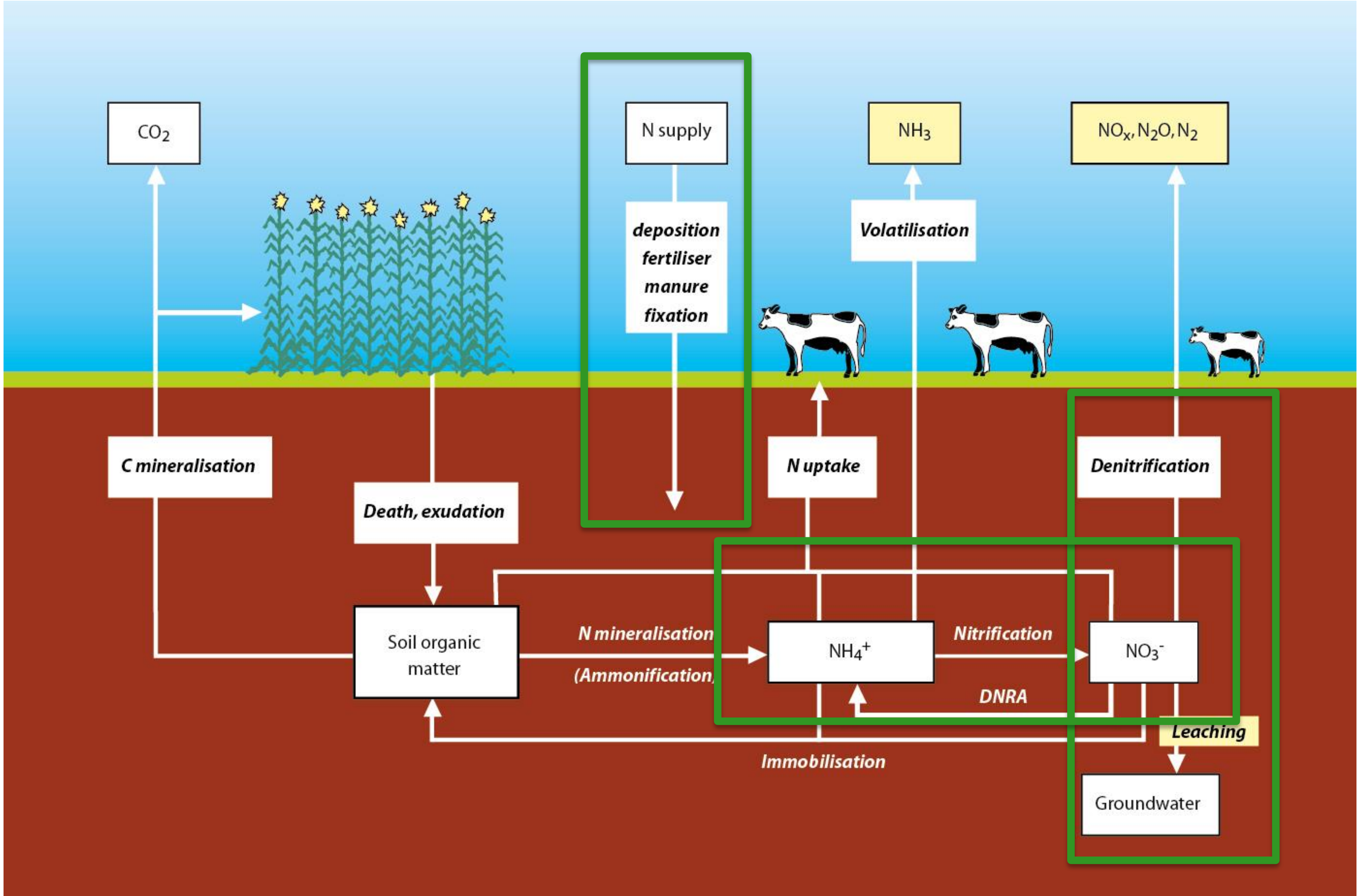
- Nitrate in the soil

- Have water percolating through the soil profile

teagasc

Agriculture and Food Development Authority

Overview of the Nitrogen Cycle



teagasc
Agriculture and Food Development Authority

How much Nitrate is acceptable?

- To protect freshwater ecology
  - 1.8mg/L N
  - 0.06 mg/L NH_4-N as N
  - 0.035 mg/L P as P

- To protect estuaries and coasts
  - 2.6 mg/L DIN as N

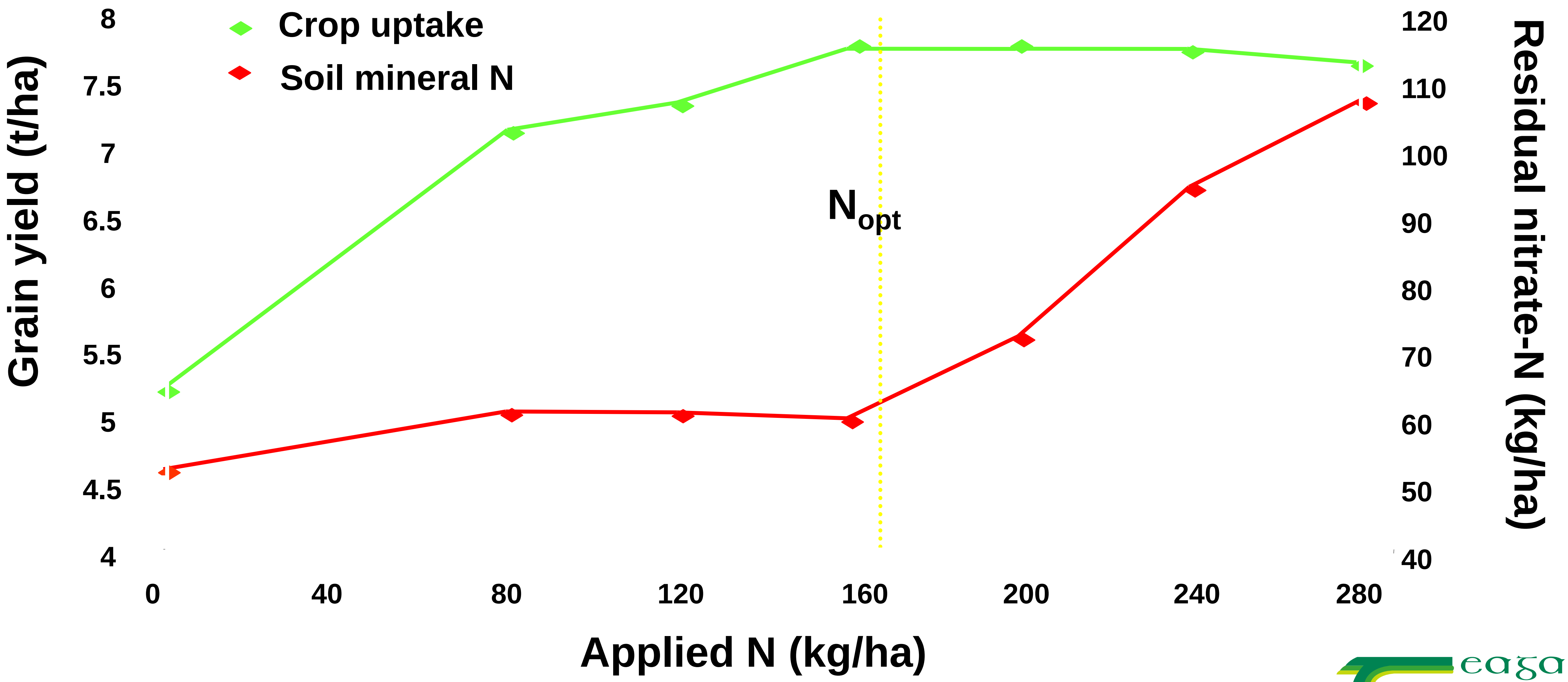
- To protect drinking water
  - Mean 8.5 mg/L NO_3-N (37.5 mg/l NO_3)
  - Maximum 11.3 mg/L NO_3-N (50 mg/L NO_3)

The European Communities Environmental Objectives (Surface Water) Regulations 2009 (S.I. 272 of 2009)

Source - What factors influence Nitrate in soil

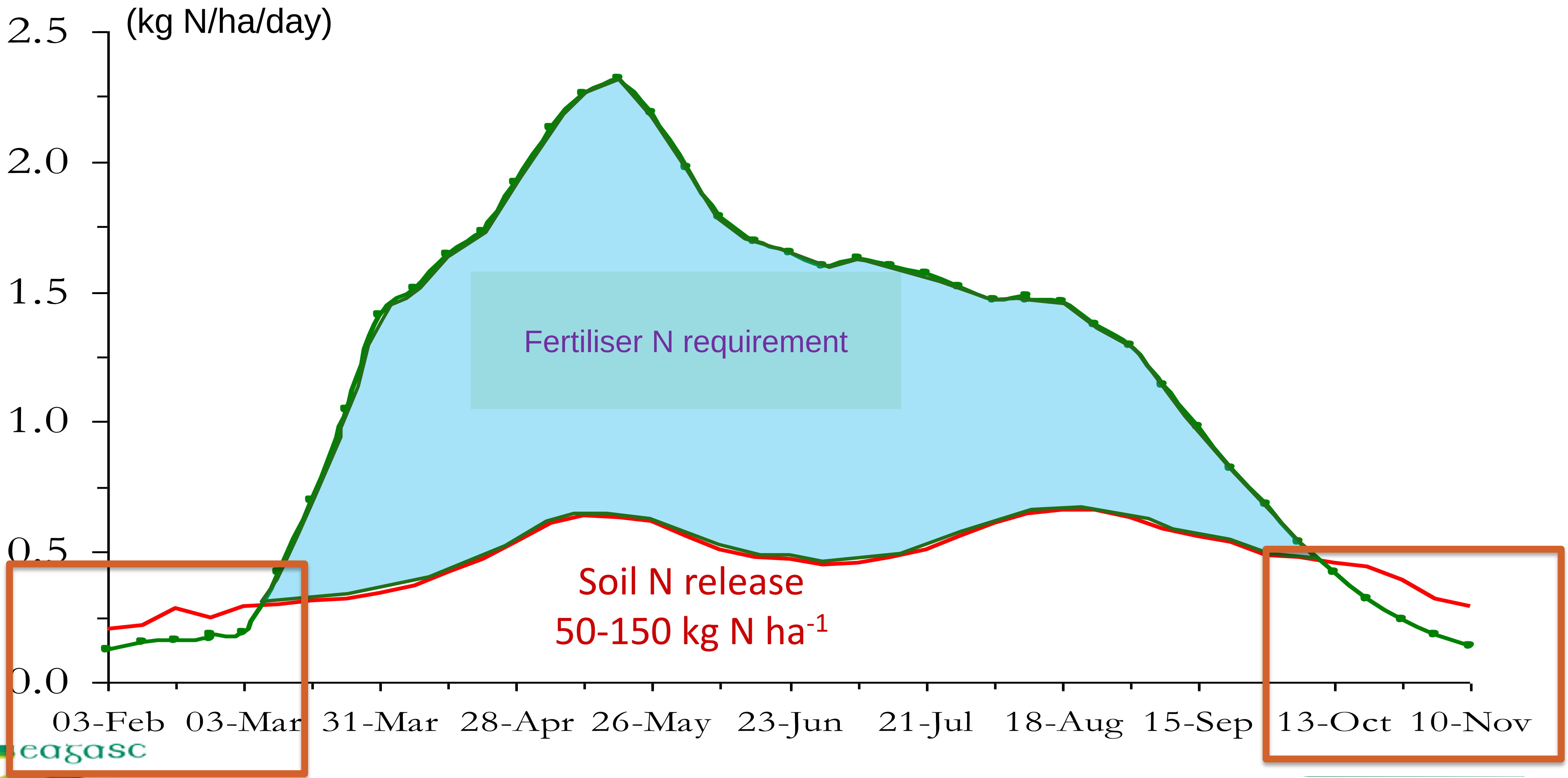
- Fertiliser/manure application rate
- Application timing (e.g. winter v spring)
- Soil nutrient status
- Crop type
- Overwinter crop cover

Fertiliser application rate



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

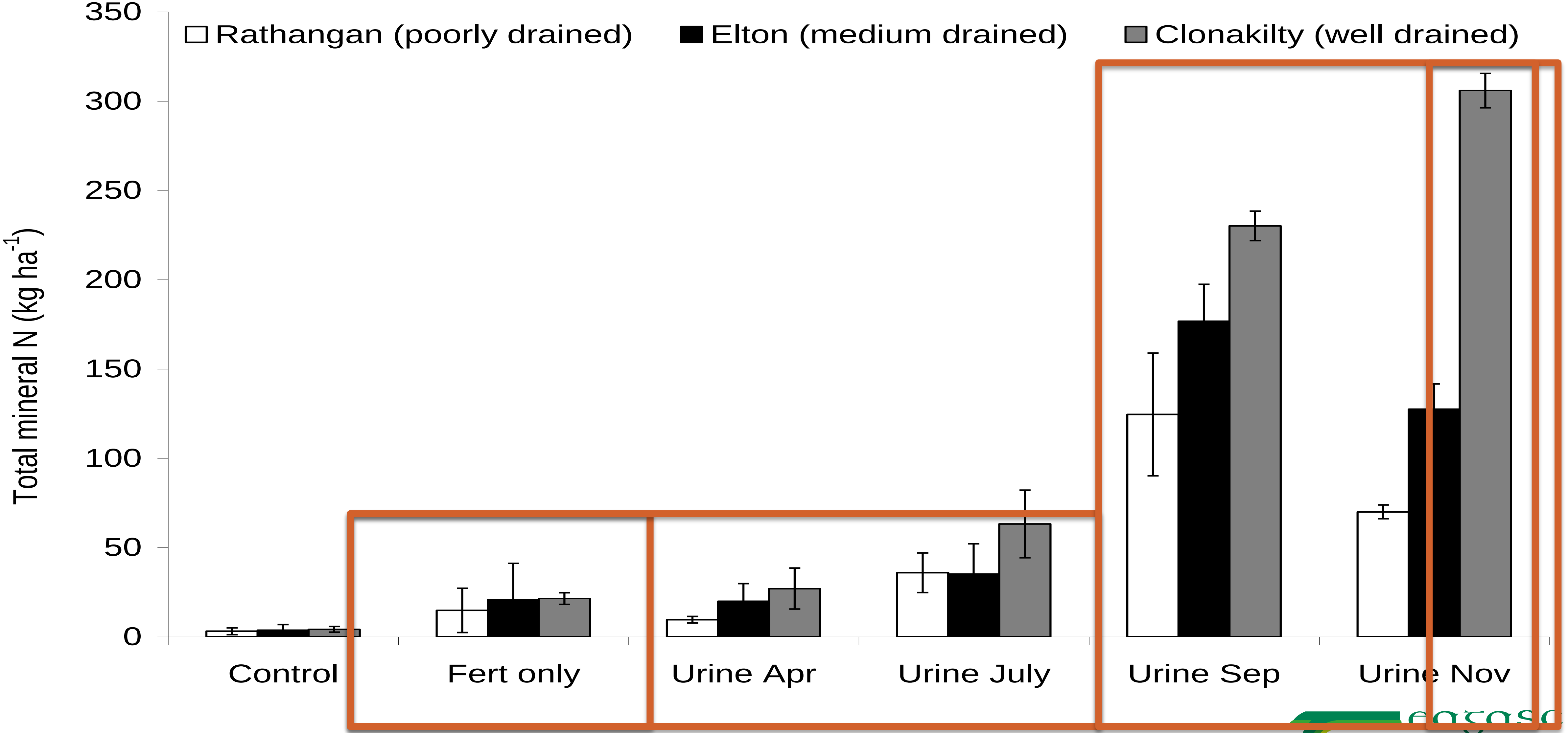
Nitrogen Application Timing



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

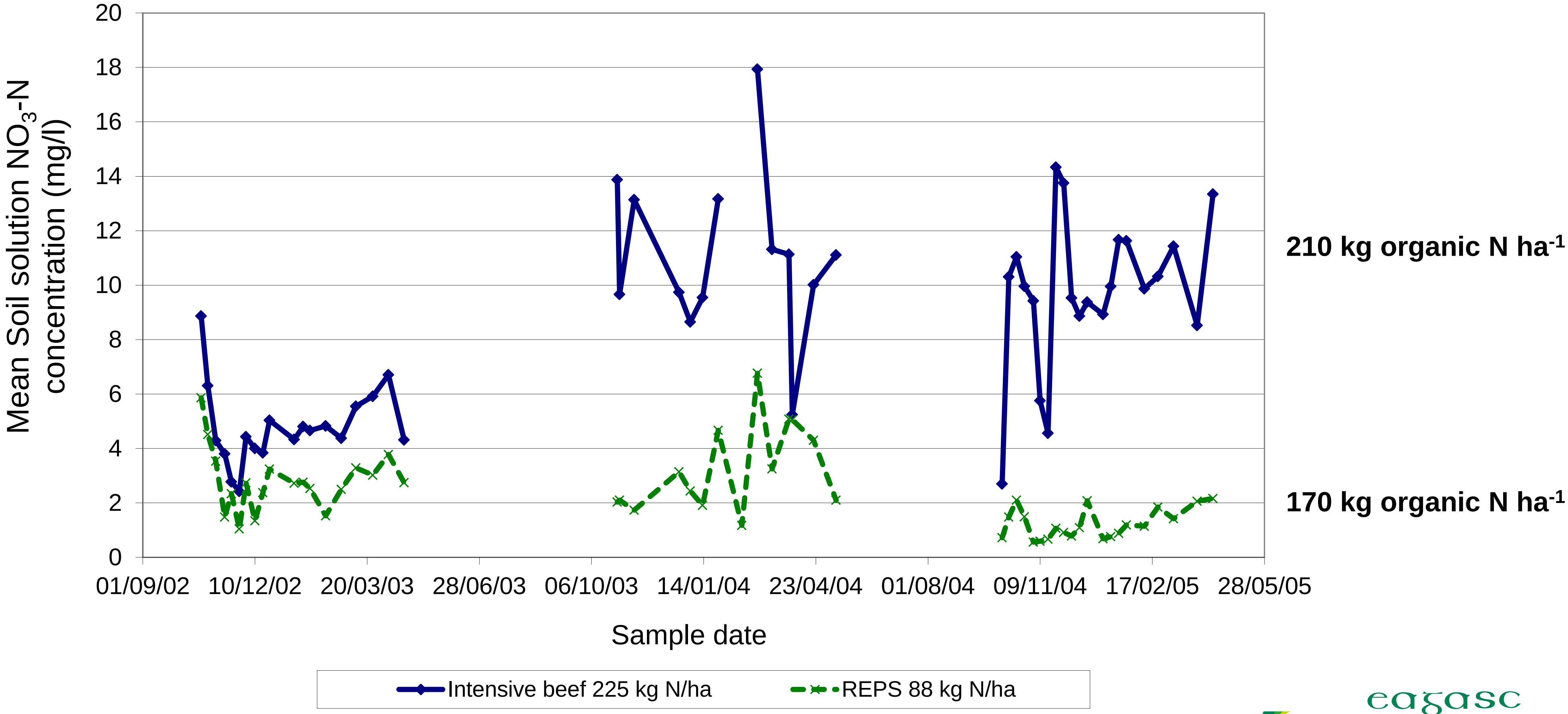
Urine timing and NO3-N leaching



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

Stocking Rate v NO3-N leaching

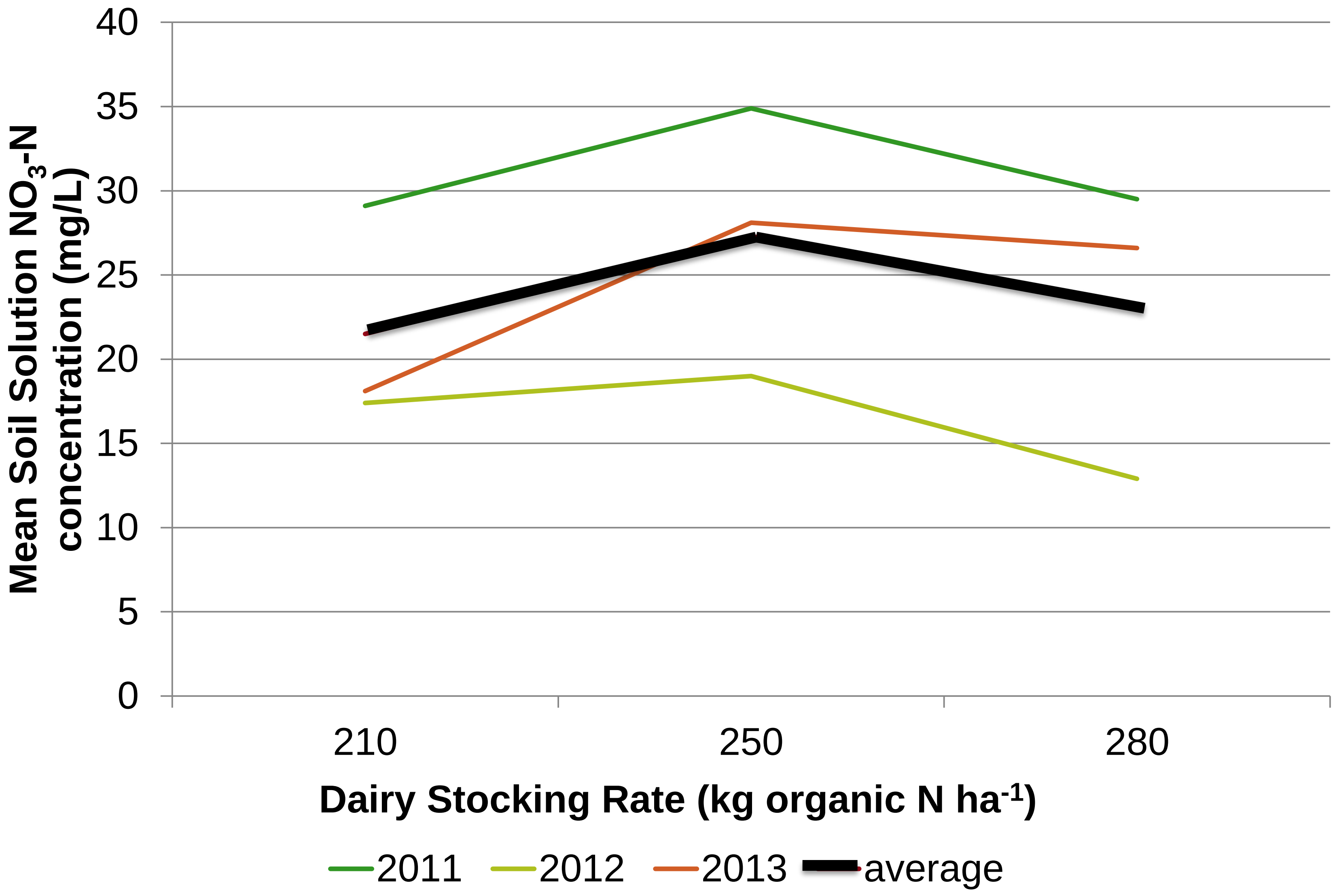
Beef Systems: 210 v 170 kg organic N ha^{-1}



Richards et al. (2015) Agriculture, Ecosystems and Environment 202 17–24

Stocking Rate – NO_3N leaching

Dairying – 3 years, free draining soil, 1m, 250 kg N ha^{-1}

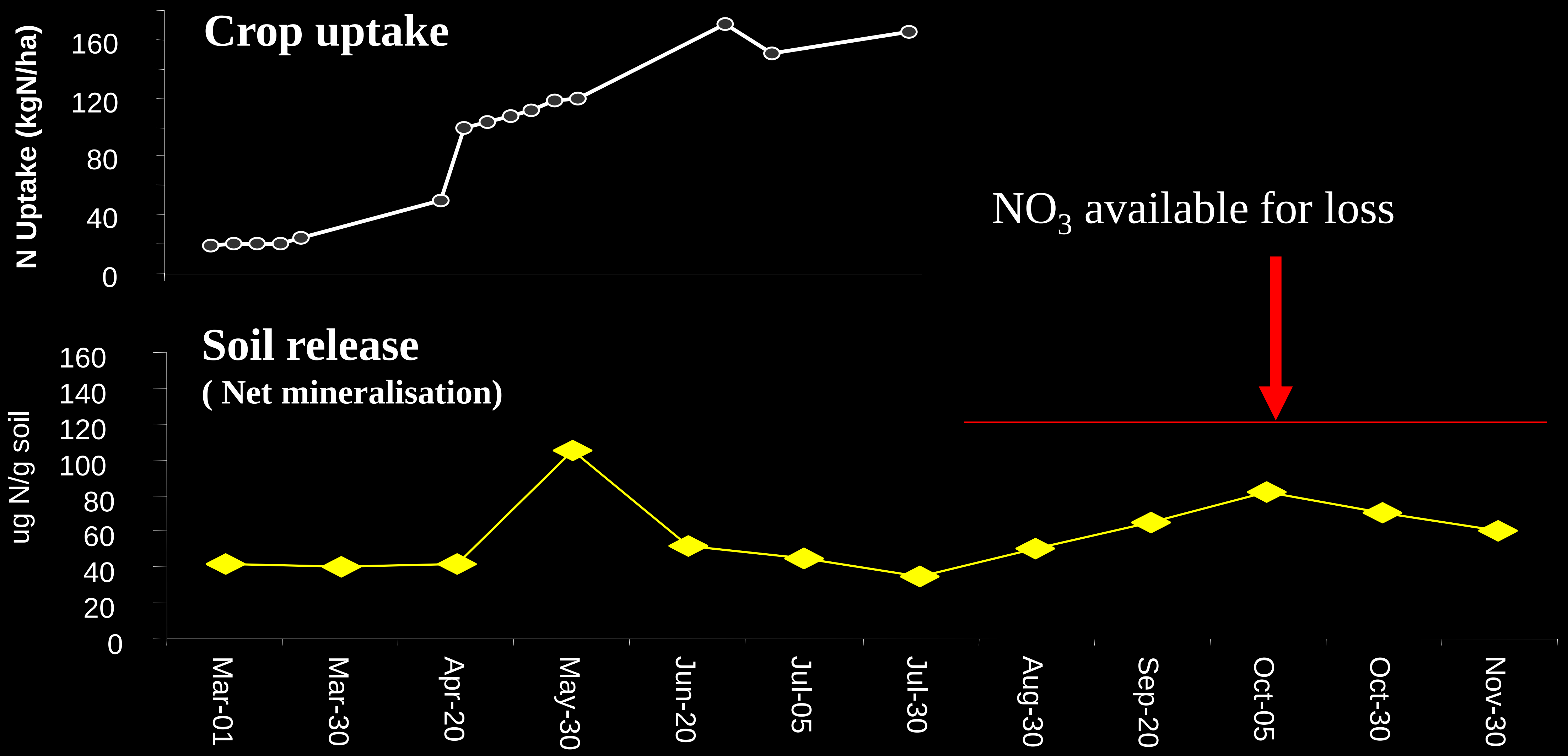


McCarthy et al 2015 J. Dairy Sci. 98 :1–14

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

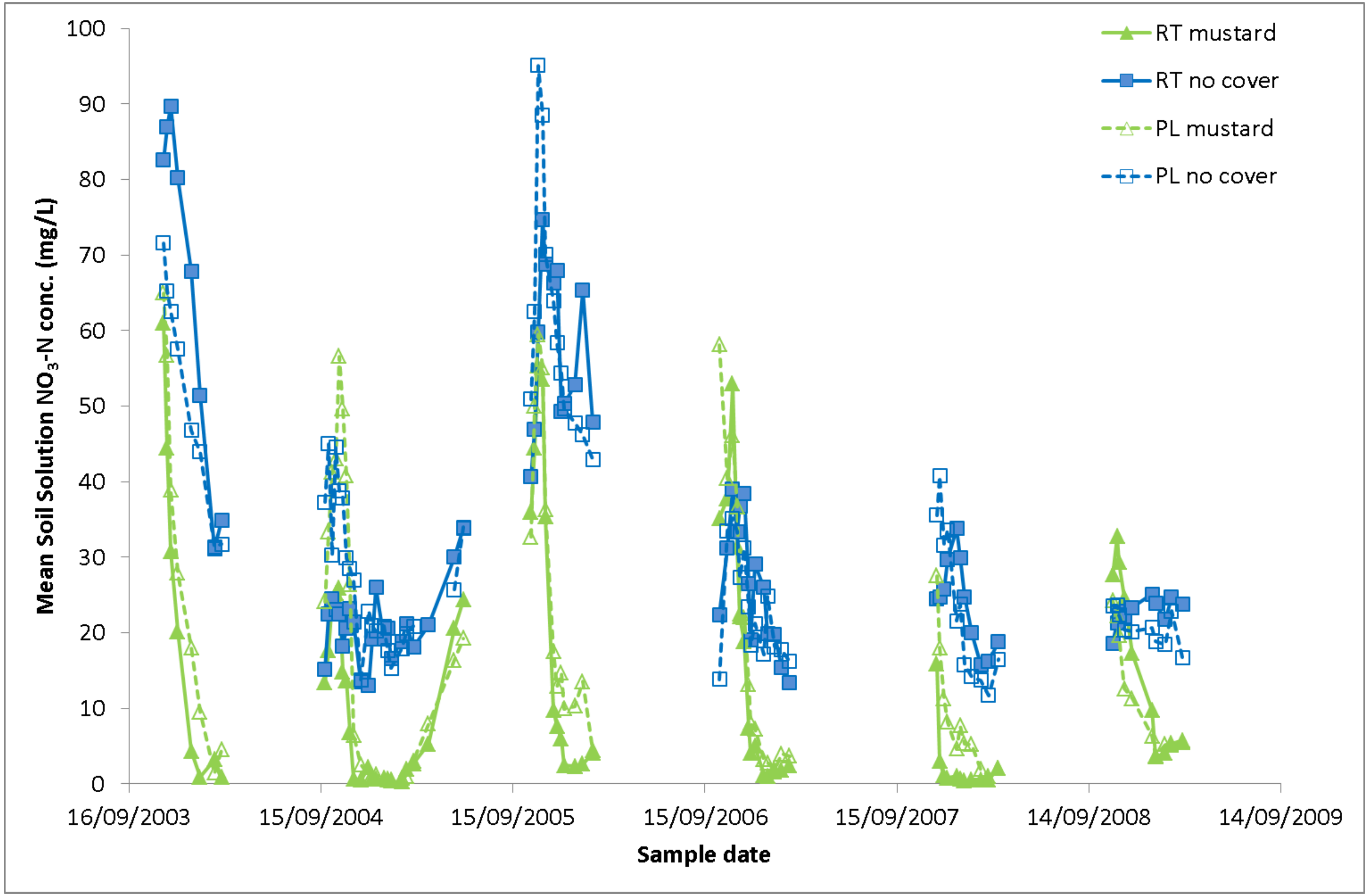
Spring Cropping System



Mustard Cover Crop

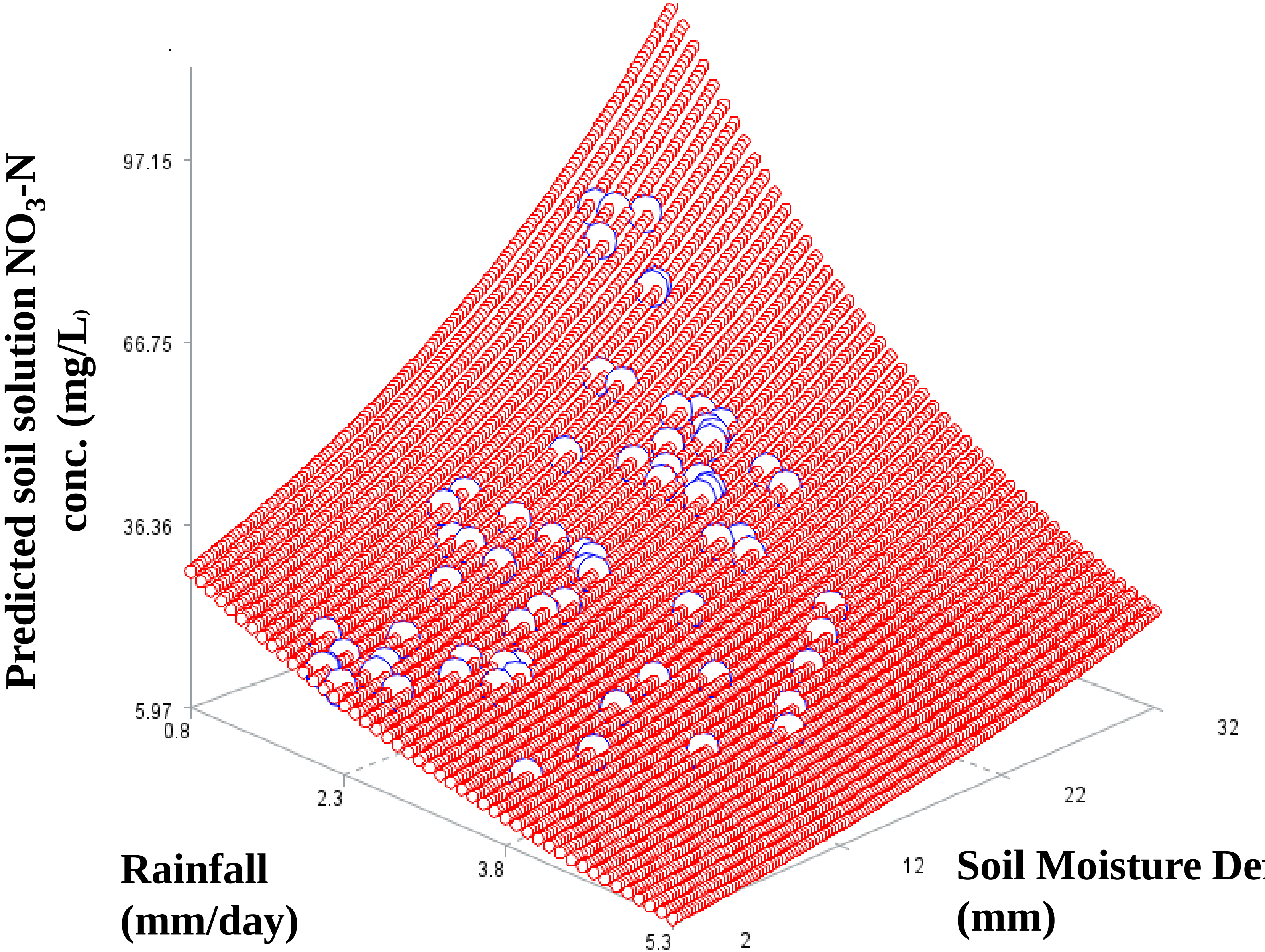
Teagasc, Oak Park

Catch crop - Mustard



Hooker et al. 2008 JEQ 37:138–145 Premrov et al. 2014 STOTEN 470–471: 967-974

Influence of SMD on NO_3-N leaching

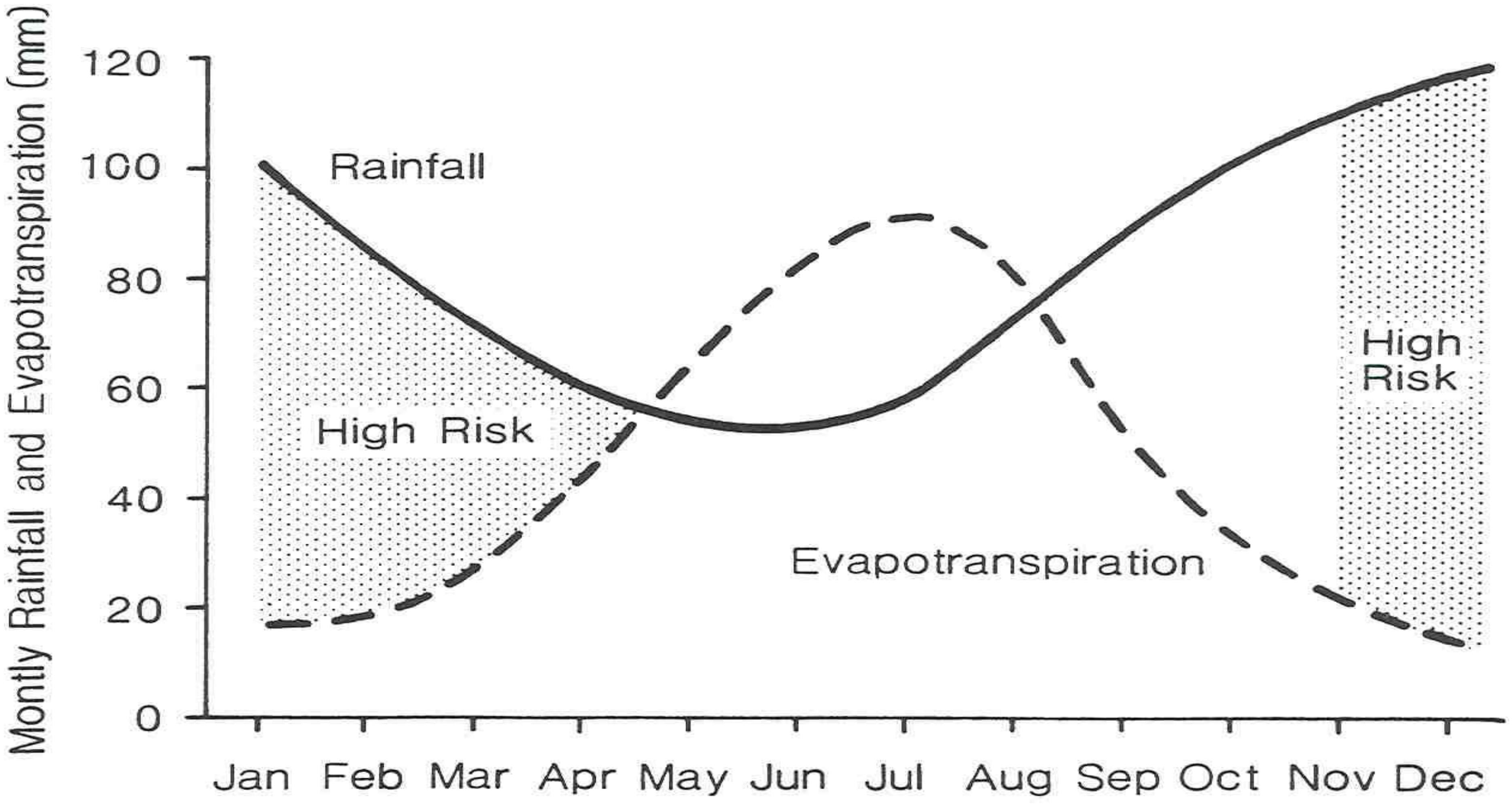


Richards In Prep

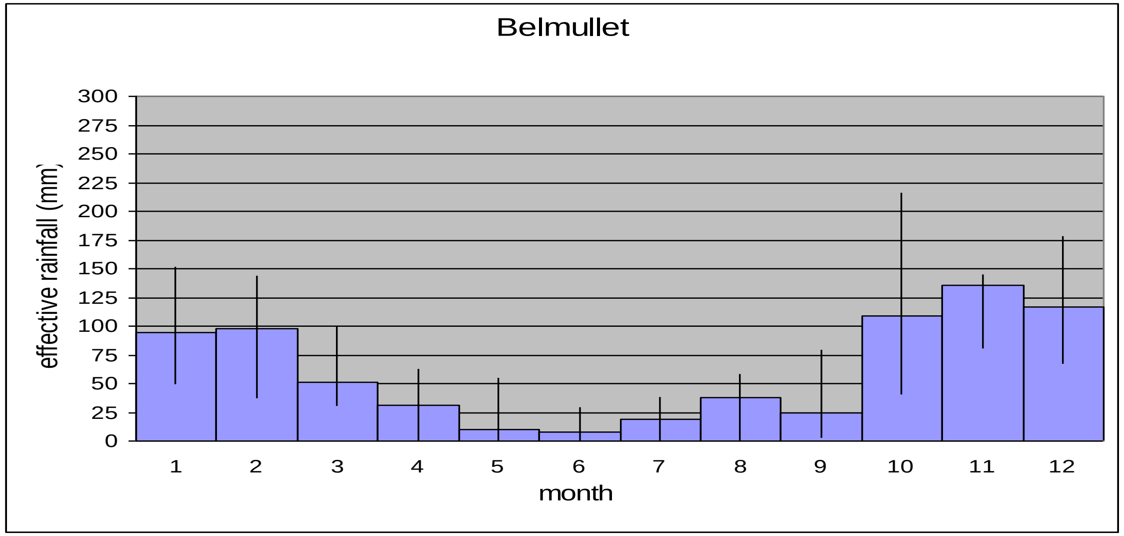
Pathway Factors

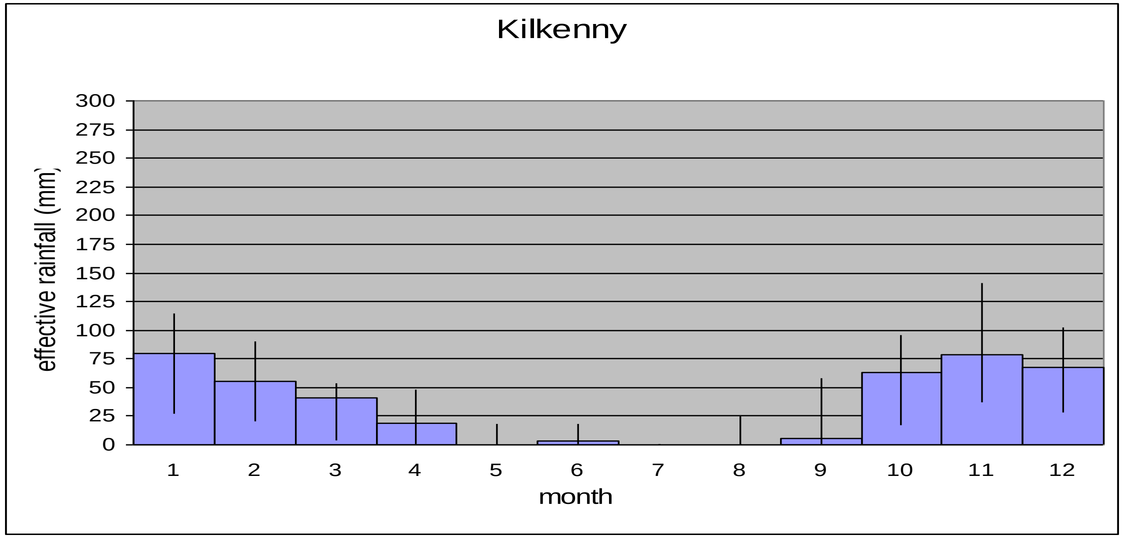
- Total rainfall (quantity and distribution)
- Effective rainfall (quantity and distribution)
- Soil type (O_2 status and WHC)
- Depth of soil/subsoil (travel time)
- Depth to water table (O_2 status + drainage)

Johnstown Castle water budget



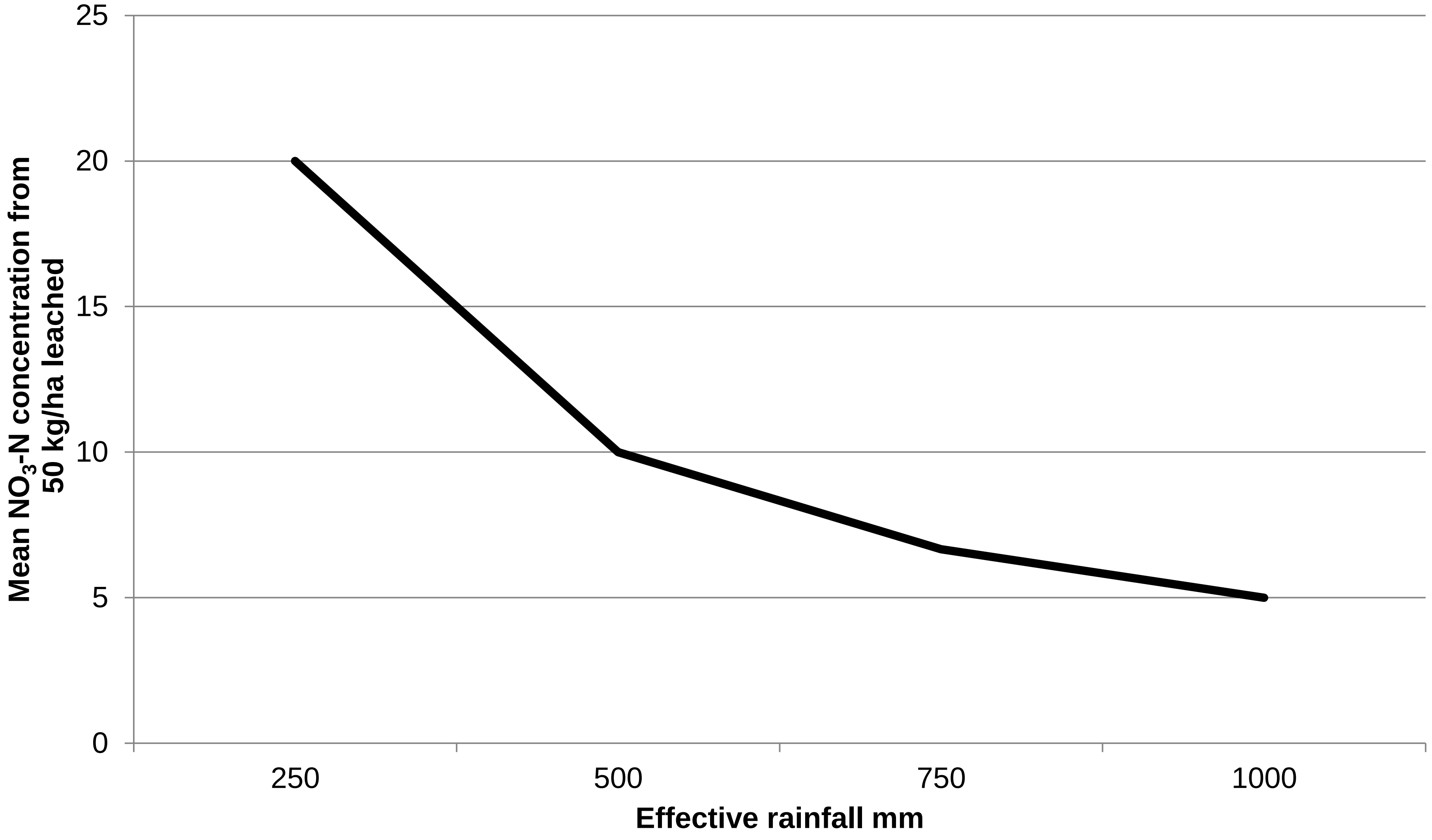
Effective rainfall distribution





Schulte et al 2006 Biology and Environment 106B 117-133

Effective rainfall impact on NO_3-N conc



Teagasc
Agriculture and Food Development Authority

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

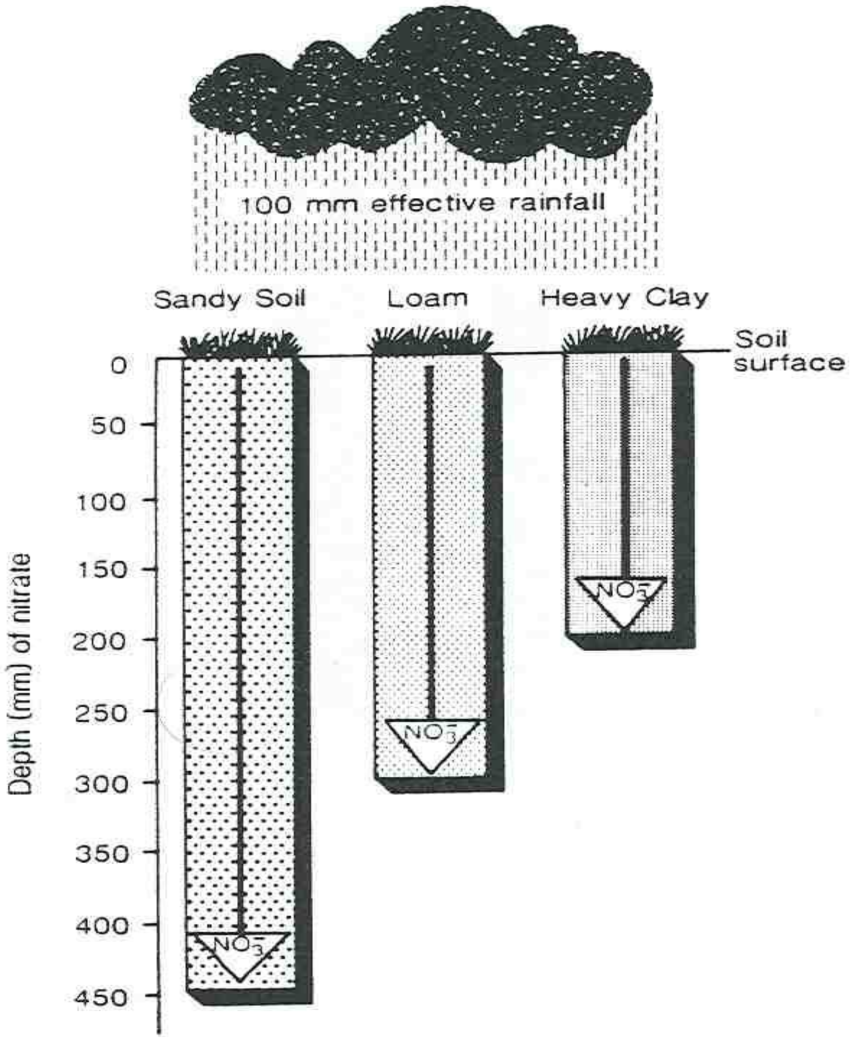


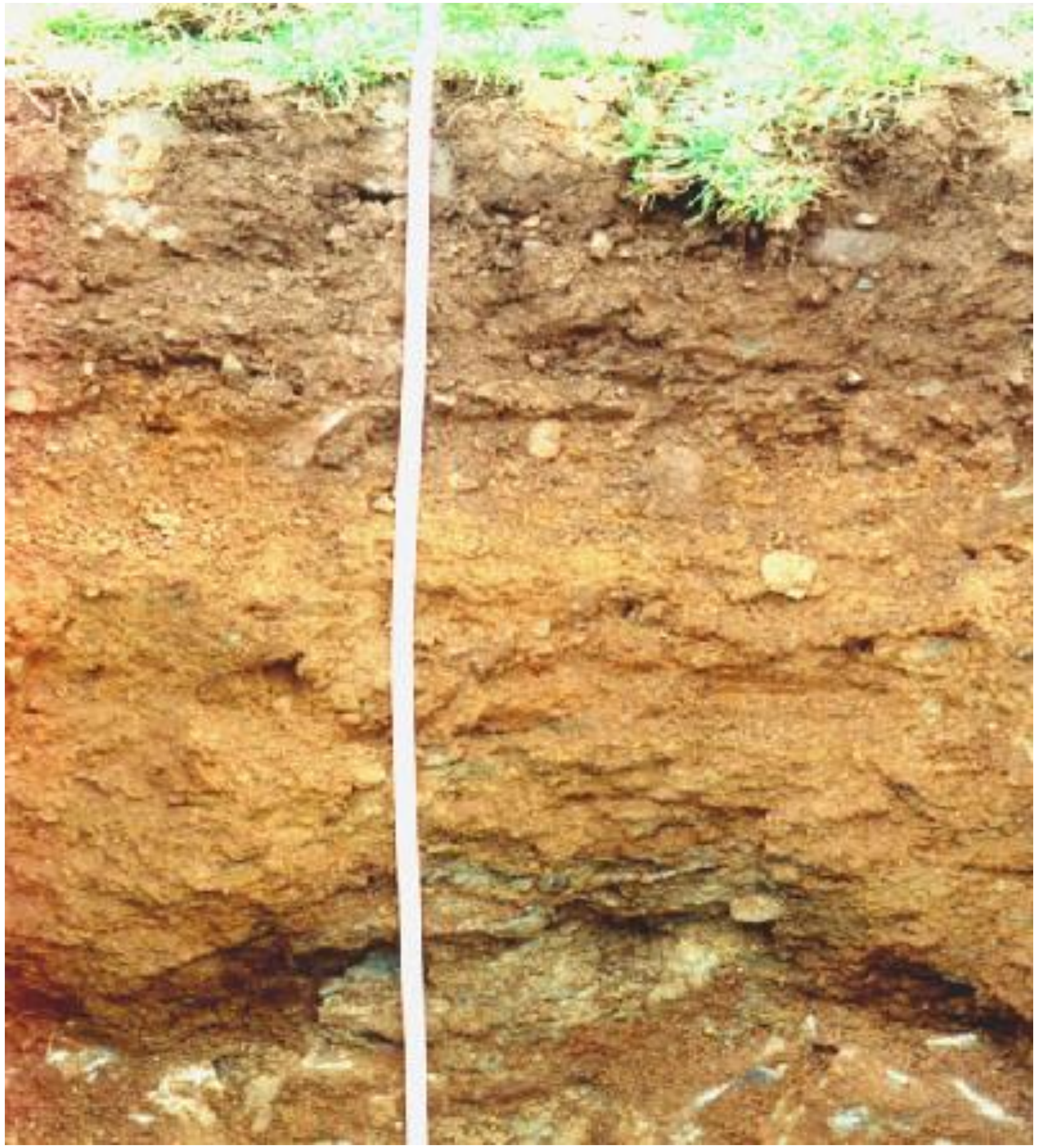
Fig. 9. Approximate depth of nitrate movement with 100 mm effective rainfall (Effective rainfall = rainfall minus evapotranspiration). Nitrate reached depth of almost 450 mm in a sandy soil while on the clay soil it hadn't reached half this depth.

Teagasc
Agriculture and Food Development Authority

Depth to water table

- Shallow WT:- runoff and denitrification
- Deeper WT:- longer travel times, attenuation
- Artificial drainage increases NO_3-N/NH_4-N delivery to surface waters
- Wet soils with high water tables can be easily identified (grey = gley soils)

Soil Depth – Travel Time



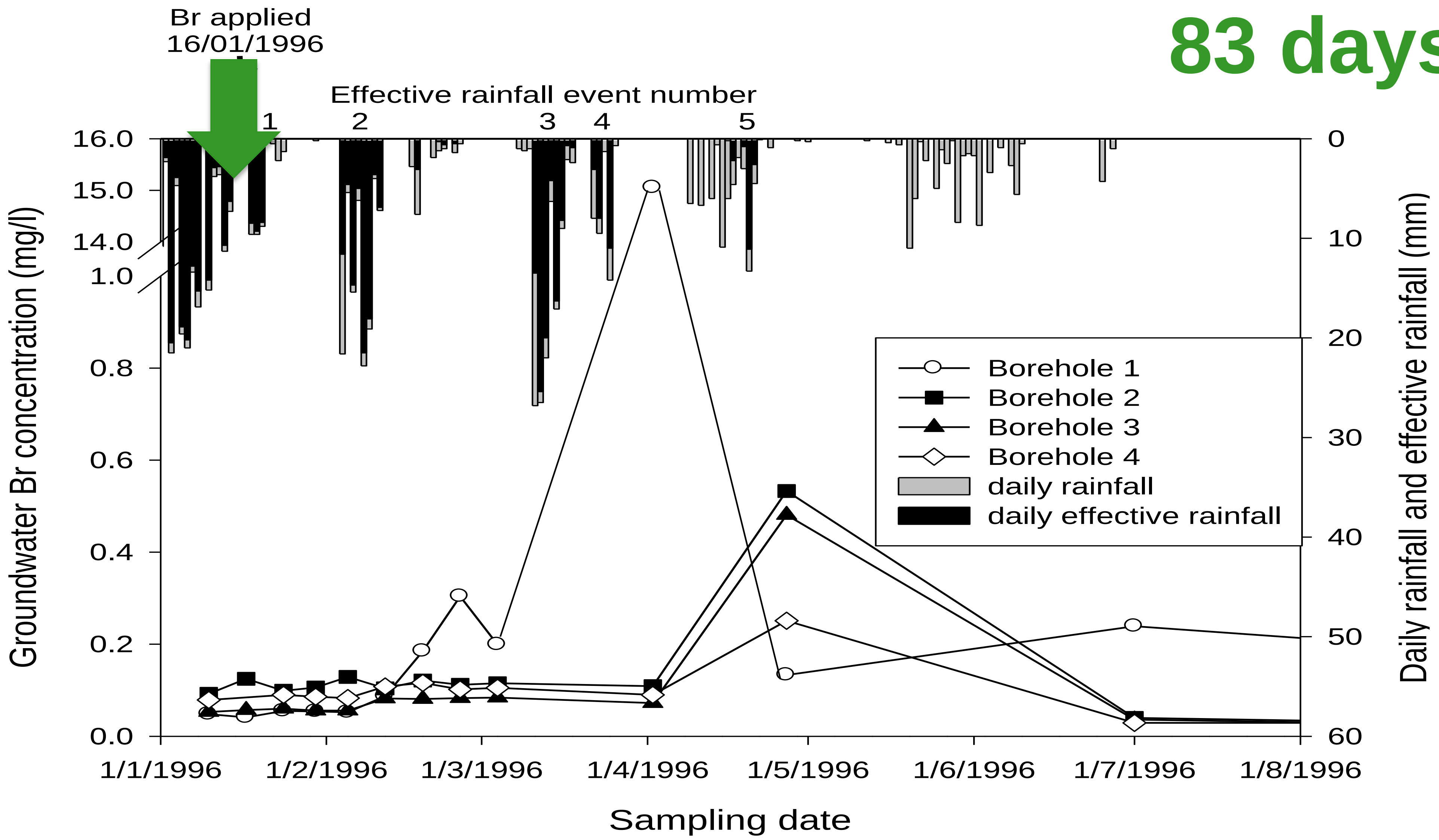
0.7 m b.g.l.

Limestone Bedrock

Teagasc
Agriculture and Food Development Authority

Travel Time to Groundwater

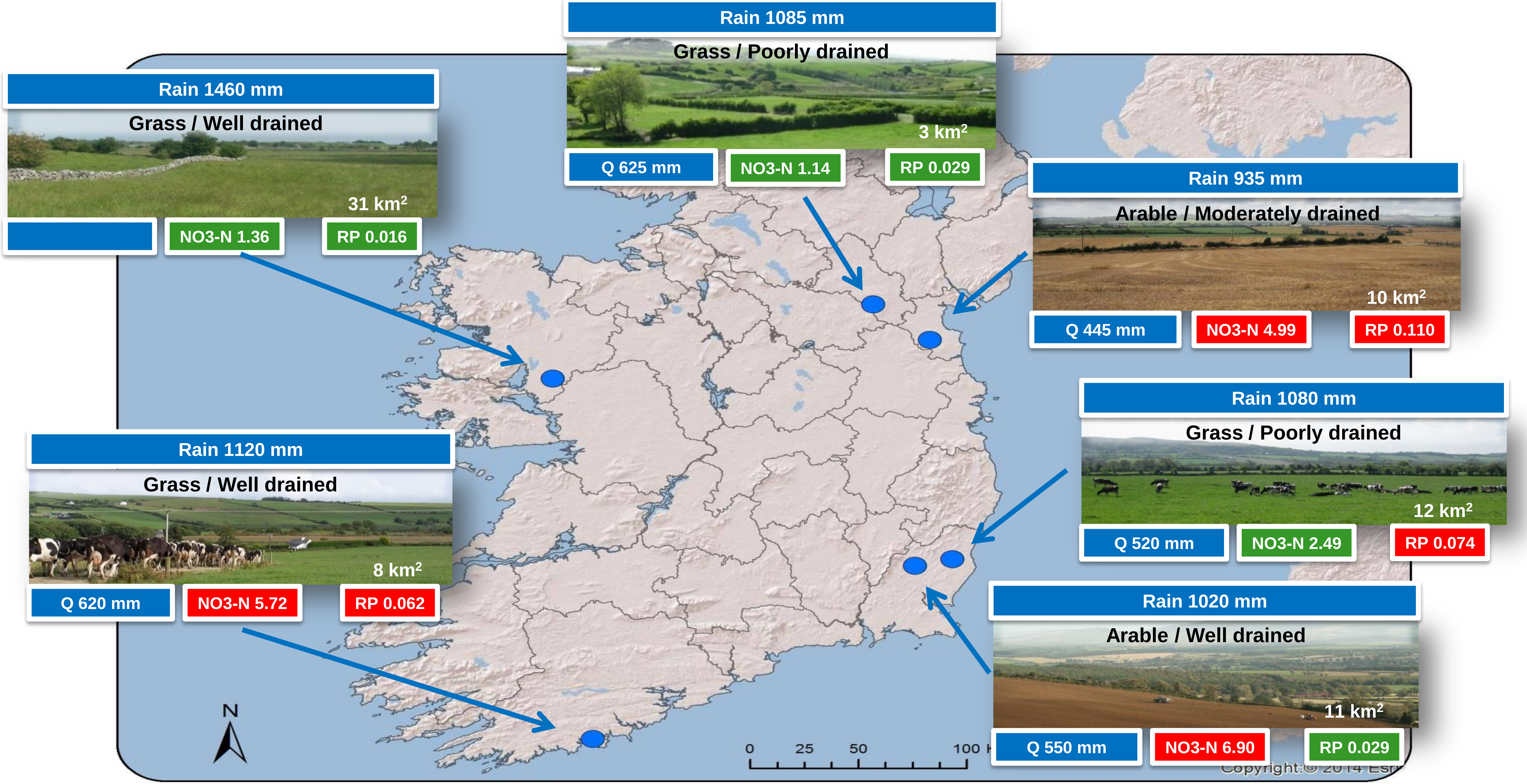
Travel time 83 days



Richards et al. (2005) Irish Geography, Volume 38(1), 57-71.

Agriculture and Food Development Authority

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