Nutrient Management at the Catchment Scale: Lessons from Ireland and the European Union

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• Ireland ratifies EU agri-environmental policies

• Common Agricultural Policy

• Nitrates Directive and cross-compliance

• Programme of Measures
  – Water Framework Directive

• Expectations of water quality improvement

• Food Harvest 2020
  Can agriculture sustainably intensify?
• Agriculture accounts for 56% of land area
• 90% managed grassland for dairy and beef (sheep)
• 10% arable for cereals, potatoes & horticulture
• 8.6% Gross Domestic Product
EU surface water trophic status

River water quality up to 2009

http://www.epa.ie/downloads/pubs/water/

The Irish Agriculture and Food Development Authority

Ceagasc
Agriculture and Food Development Authority
Average NO$_3$ mg/L
- < 25
- 25 to 40
- 40 to 50
- > 50

Ireland GW quality 2004-2007
2.6% >50mg/L
Groundwater quality up to 2009

2007-2009
1.8% >50mg/L

http://www.epa.ie/downloads/pubs/water/

The Irish Agriculture and Food Development Authority
Estuarine eutrophication

2007-2009
5.3% eutrophic or potentially eutrophic

\[ n = 89 \, (2,000 \text{km}^2) \]

http://www.epa.ie/downloads/pubs/water/
Nitrates Directive

• Statutory Instrument - National Action Programme

• Constrains the use of N and P in inorganic and organic fertilisers
  Closed spreading periods
  Slurry storage
  Livestock intensity
  Soil nutrient status (P) and nitrogen use

• Constrains ploughing periods

• Supports a derogation (2007/967/EC) on livestock intensity
  170kg ON/ha to 250kg ON/ha
  20% of Livestock Unit (up to 10,000 cattle holdings)

• Requires a catchment scale evaluation
• **Point-source losses**
  Farmyards
  Excessive rates of soiled water (stationary)

• **Incidental losses**
  Direct losses of fertiliser / manures to water

• **Diffuse losses** (majority)
  Losses from soil
  Related to soil P and N concentrations in excess of crop requirements

How does the NAP address these risks?
Point source losses

- €2.5bn investment in storage facilities and farmyard infrastructure (winter housing)
- Storage requirements for soiled water
- Farm Facilities Survey (2010): very high rate of compliance
Incidental losses

- Buffer strips for water courses (1.5m – 200m)

- “Closed periods” for landspreading
  - fertiliser: 15 September – 12/31January
  - slurry: 15 October – 12/31January
  - FYM: 1 November – 12/31January
Diffuse losses (high soil nutrient levels)

• Restrictions to stocking rates (170kg ON/ha)
• Maximum fertilisation rates = crop requirement
• No external nutrient inputs on P index 4 soils

**Frequency distribution of soil test P 2005**

- **Index 1:** deficient
- **Index 2:** low
- **Index 3:** optimum
- **Index 4:** excessive

Soil Test P (Morgan's) (mg/l)

- 0-1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-6
- 6-7
- 7-8
- 8-9
- 9-10
- >10

Percentage of soil samples

Increasing risk

**Coulter & Lalor, 2008**

**Carton et al., 2008**
National Fertilizer Usage 1970-2010

Source: DAFM

[Graph showing national fertilizer usage from 1970 to 2010 with lines for N, P, and K nutrients, indicating trends and changes over time.]
Fertilizer use has decreased in Ireland

% change in fertilizer N P and K usage between 2003 and 2008

Source: Lalor et al 2010
Soil Fertility Trends - P
(2007-2011)

Source: Teagasc
Improved use of cattle slurry

• Timing of slurry application critical for N use efficiency and fertilizer replacement

• Farmers have adapted practice to make better use of slurry as an N fertilizer source

<table>
<thead>
<tr>
<th>N fertilizer replacement value (%)</th>
<th>Spring</th>
<th>Summer</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slurry application timings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>35 %</td>
<td>44 %</td>
<td>Farm facilities surveys 2003 and 2009</td>
</tr>
<tr>
<td>2009</td>
<td>52 %</td>
<td>36 %</td>
<td></td>
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</tbody>
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Lalor et al, 2011 (JEQ)
Advice and education
Nitrates warning for 11,000 farmers

Nearly 11,000 farmers have been identified by the Department as being on course to break Nitrates limits in 2011.

The Department is sending out 10,800 letters to livestock farmers warning them that, based on the land they declared for the 2011 Single Farm Payment and the cattle they have on the AIM system in the first seven months of the year, they are likely to be over the statutory limit of 170kg of organic nitrogen per hectare.

The letters, sent one month earlier than previous years, are aimed at giving an early warning to help herdowners, and allow them time to take corrective action to avoid a penalty.

Approximately 6,000 of these farmers have applied, and are eligible, for a derogation of up to 250kgN/ha.

However, in some cases, the records identify that they could even breach this limit.

The calculations are based on cattle only so farmers also have to take into account the N figures for the other livestock on their holding such as sheep, pigs, poultry, horses, etc.

The letter outlines that farmers can take corrective action before the end of the year by:
- Reducing stock numbers.
- Short-term grazing/rental agreements
- Complete a Record 4 form, if moving cattle to a farm that does not keep any bovines, and submit this form to Nitrates Section prior to movement.
- Complete a NBAS 31B if moving animals to a farm that keeps bovines.
- Submit a short-term rental agreement.

Export of slurry — Forms for the movement of organic fertilizer must be submitted to Nitrates Section on or before 31 December 2011. Export forms received after that date will be rejected.

Derogation applicants are also required to submit fertilizer accounts by the following March.

In circumstances where they are not submitted within a reasonable time, the derogation is withdrawn for the year in question and they are treated as non-derogation, i.e. have to stay within 170kg N/ha.
Nitrates Directive as a WFD Programme of Measures

Evaluated from national inventories to focused catchment studies

Sources
Mobilisation

Pathways

Delivery

Impacts

NAP measures

WFD standards

The Irish Agriculture and Food Development Authority
Nitrates Directive as a WFD Programme of Measures

Evaluated from national inventories to focussed catchment studies

- **Sources**
  - Whole catchment audits

- **Mobilisation**
  - Demonstration studies

- **Pathways**
  - Delivery

- **Impacts**
  - River ecology
  - Assessments of downstream impacts

Wall et al., 2011; ES&P
Catchment scale:
- Small enough to be manageable
- Large enough to be meaningful
- Area 4-12km² and stream order ≤3
1. Arable – P risky [9]
5. Grassland – N risky [8]
6. Grassland – P risky [30?]

Karst

(Fealy et al., 2010; SUM)
Two emerging issues:

- Soil P index 4
- Closed period
• Exponential decline of soil P with zero amendment

(Schulte et al., 2010; ES&P)
• Morgan P: 8mg L$^{-1}$ boundary of optimum

(Schulte et al., 2010; ES&P)
Arable A (well drained)

Year

Proportion of Index 4 soils still in Index

- S1 -30 kg/ha/yr
- S2 -15 kg/ha/yr
- S3 -7 kg/ha/yr
Total P (Fay et al., 2008)
Synchronous discharge and chemistry monitoring
Sub-hourly
- P fractions
- N fractions
- Turbidity
- Conductivity
- Temperature
- Telemetry etc

Cassidy and Jordan, 2011; JoH
2010 - 2011

- 510mm yr\(^{-1}\)
- 32% during closed period

- 413mm yr\(^{-1}\)
- 47% during closed period
2010 - 2011

- c.300 kg N ha\(^{-1}\) input
- 27 kg TON ha\(^{-1}\) yr\(^{-1}\)
- 32% export during closed period

- c.130 kg N ha\(^{-1}\) input
- 9 kg TON ha\(^{-1}\) yr\(^{-1}\)
- 47% export during closed period
2010 - 2011

- 26% P index 4 soils
  - 0.54 kg TP ha\(^{-1}\) yr\(^{-1}\)
  - 40% export during closed period

- 6% P index 4 soils
  - 0.70 kg TP ha\(^{-1}\) yr\(^{-1}\)
  - 48% export during closed period
2010 - 2011

- Export standards?

- 6% P index 4 soils
- 0.70 kg ha\(^{-1}\) yr\(^{-1}\)
- 48% TP export during closed period
2010 - 2011

• Runoff flashiness

\((n = 2,160\text{hrs})\)
Low flow P

Arable B 09/03/10 to 30/03/10

P concentration, mg L⁻¹

Discharge, m³ s⁻¹

- TP
- TRP
- Q
Low flow P

TP concentration in flows <0.09 m³ s⁻¹

Septic system density, km⁻²

- 2006-07
- 2009-10
Summary

- Nutrient management is constrained by agri-environmental policy
- Adaptations occurring anyway
- Expectations of water quality status using layered approach:
  - source to impact continuum
  - national inventories
  - catchment studies (guides expectations, questions metrics)
  - biophysical and socio-economic
- Lag times important and confounding influences
  - climate (change) and soil hydrology
  - rural point sources
- Spatial considerations – ‘critical source areas’
Summary

• Food Harvest 2020

Where and how
Can agriculture sustainably intensify?

www.teagasc.ie/agcatchments
Summary

www.teagasc.ie/agcatchments

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