The Role of Cover Crops in Mitigating Nitrate Loss from Tillage Systems

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Structure of Talk

- 1. Introduction
- 2. Cover Crop Modelling
- 3. Catchment Scale Modelling: ACP
- 4. Slaney Catchment Assessment
- 5. Catchment Scale Modelling: Slaney
- 6. Conclusions

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1 Introduction

- Cover crops can be sown before a main (spring) tillage crop in order to reduce nutrient losses (mostly N, but also P and sediments from fields).
- Additional benefits to farmers include improved soil health, the retention of topsoil and carbon sequestration over time.
- Cover crops have been implemented on farms through various agri-environment schemes, e.g. Water-EIP (RBMS). Only cover cropping before spring sown crops are considered here.
- This presentation will explore the benefits of cover crops for achieving nitrogen reductions in waterbodies in an area of south-east Ireland.
- The research used water quality modelling combined with agronomy data taken from Teagasc research.

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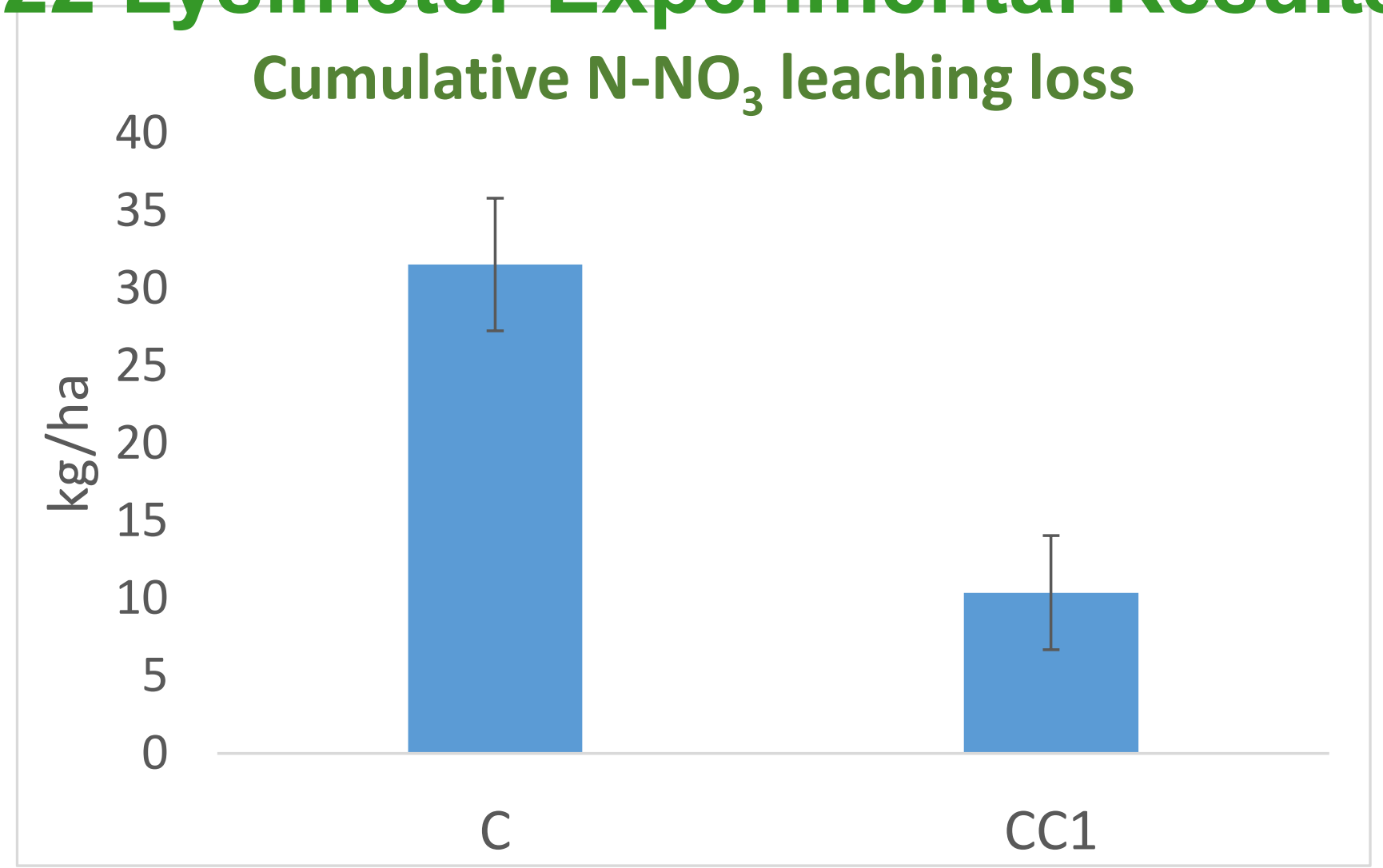
2022 Lysimeter Experimental Results



"C" = Control, left fallow under natural cover regeneration
"CC1" = Cover crop mix, shallow cultivation

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Modelling Concepts

- Catchment Water Quality Models: Tools to investigate scenarios to reduce nutrient pollution.
- Models can feed back information to farmers, advisors and policy makers
- Example of a scenario: Sowing of cover crops (CC) after harvest
- Model simulated first for a “Baseline” - with no CC, then the CC scenario
- Simulations: Wexford ACP catchment: 1 (Castledockrell 11.2 km^2) nested within Slaney sub-catchment
- Then the Slaney River (to Scarawalsh 1030 km^2) was modelled

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2: Cover Crop Modelling

- Modelling aim: Scenario to assess impact of CC's with spring crops i.e. spring barley (SB).
- Catchment selected: ACP Castledockrell (climate data)
- 2 baseline scenarios with different levels of inorganic N application rates (135 and 155 kg N/ha) applied to SB.
- 2 different CC sowing dates (mid-Aug. & mid-Sept.) were also modelled.
- Teagasc agronomy data used to fit modelled N uptake for SB and for CC's.

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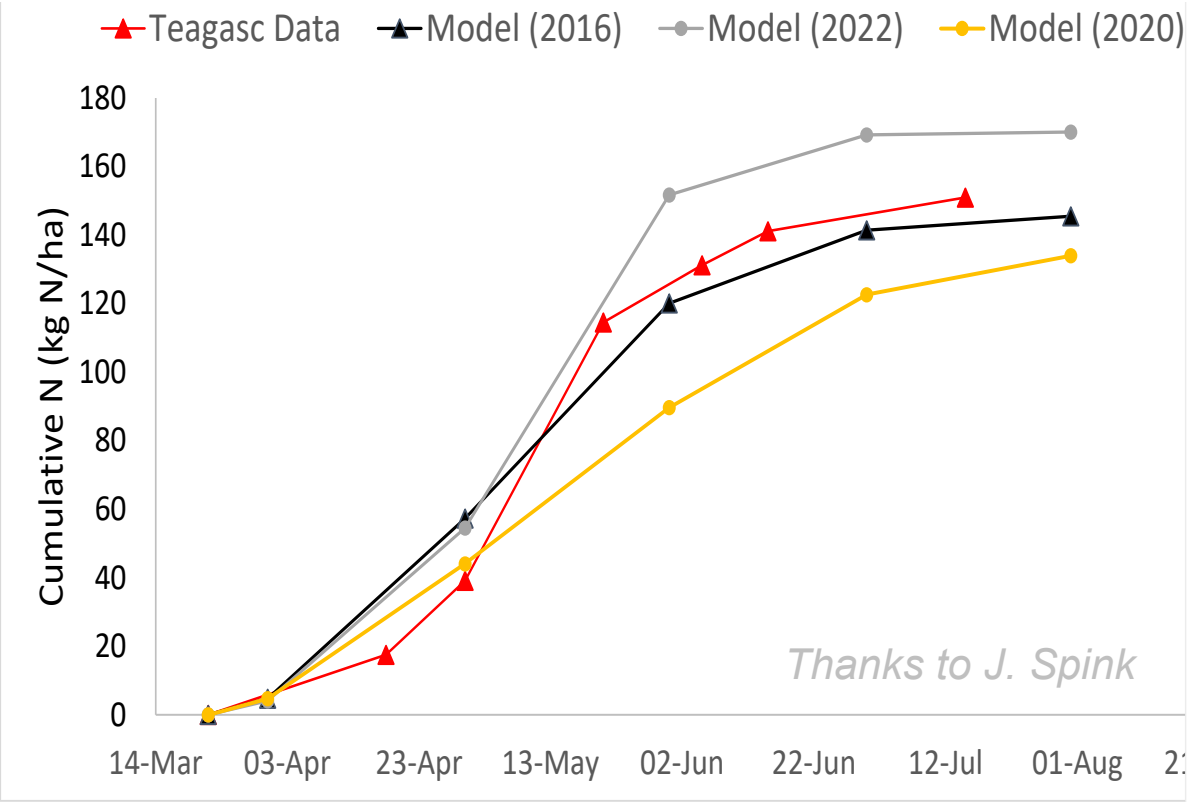
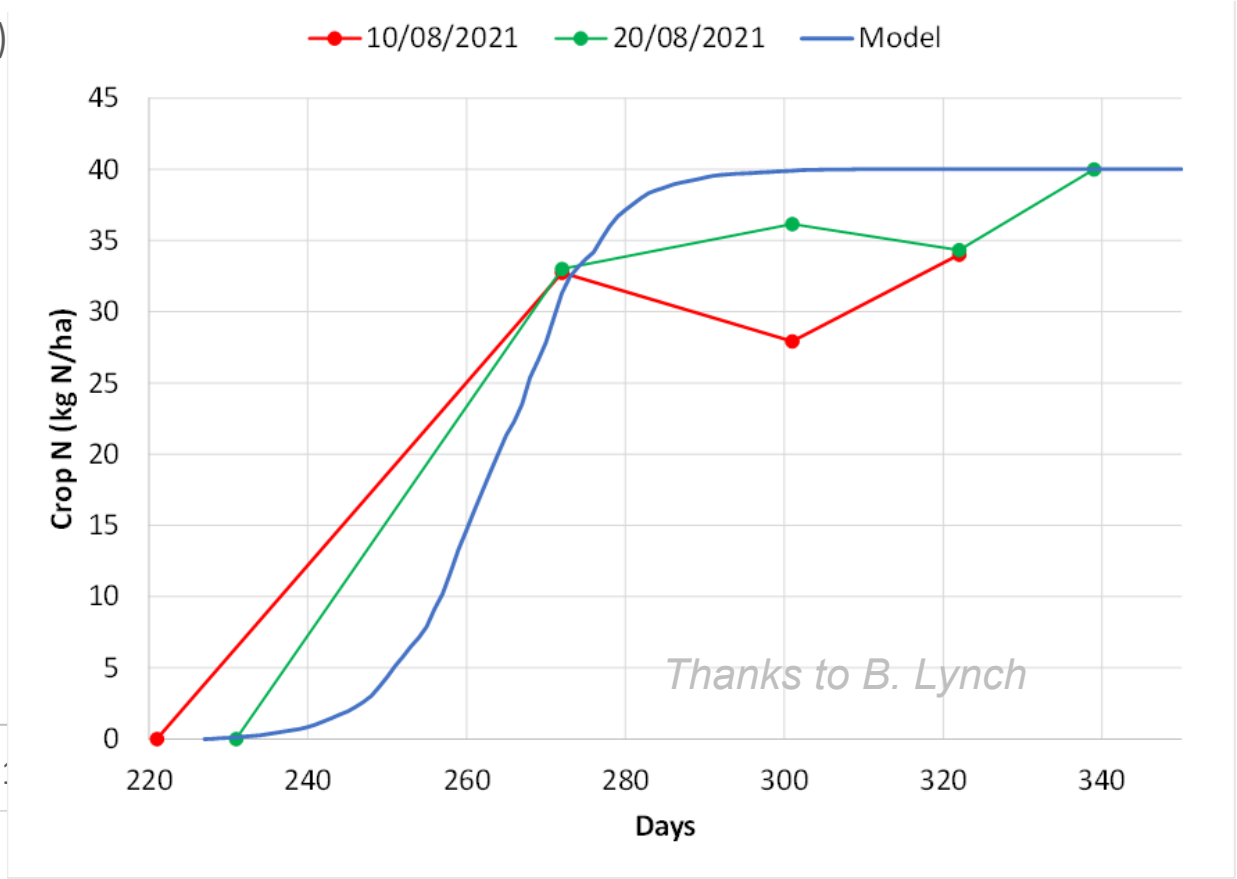
Crop N Uptake Functions

Spring Barley



Cover Crop (Brassica)



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Description of Scenario	Total annual Inorganic N (kg N/ha)	Mean annual Uptake (range) (kg N/ha)	Mean annual C.C Uptake (range) (kg N/ha)	Mean annual N loss from Soil (kg N/ha)	Change in N loss relative to baseline (%)
Baseline 1 S-B	135	148.6 (135-165)	0	12.7	------
Cover crop - early sown (CC1)	135	165.7 (164-168)	21.8 (9.9-30.7)	4.6	**-63.8**
Cover crop - late sown (CC2)	135	165.8 (165-168)	22.4 (10.5-30.6)	5.0	**-60.7**
Baseline 2 (High) S-B	155	159.2 (140-180)	0	19.7	------
Cover crop - early sown (CC1) (H)	155	184.5 (180.7-187.1)	29.7 (13.5-46.3)	6.2	**-68.5**
Cover crop - late sown (CC2) (H)	155	183.5 (181-186.3)	29.6 (14.1-43.5)	6.7	**-66.0**

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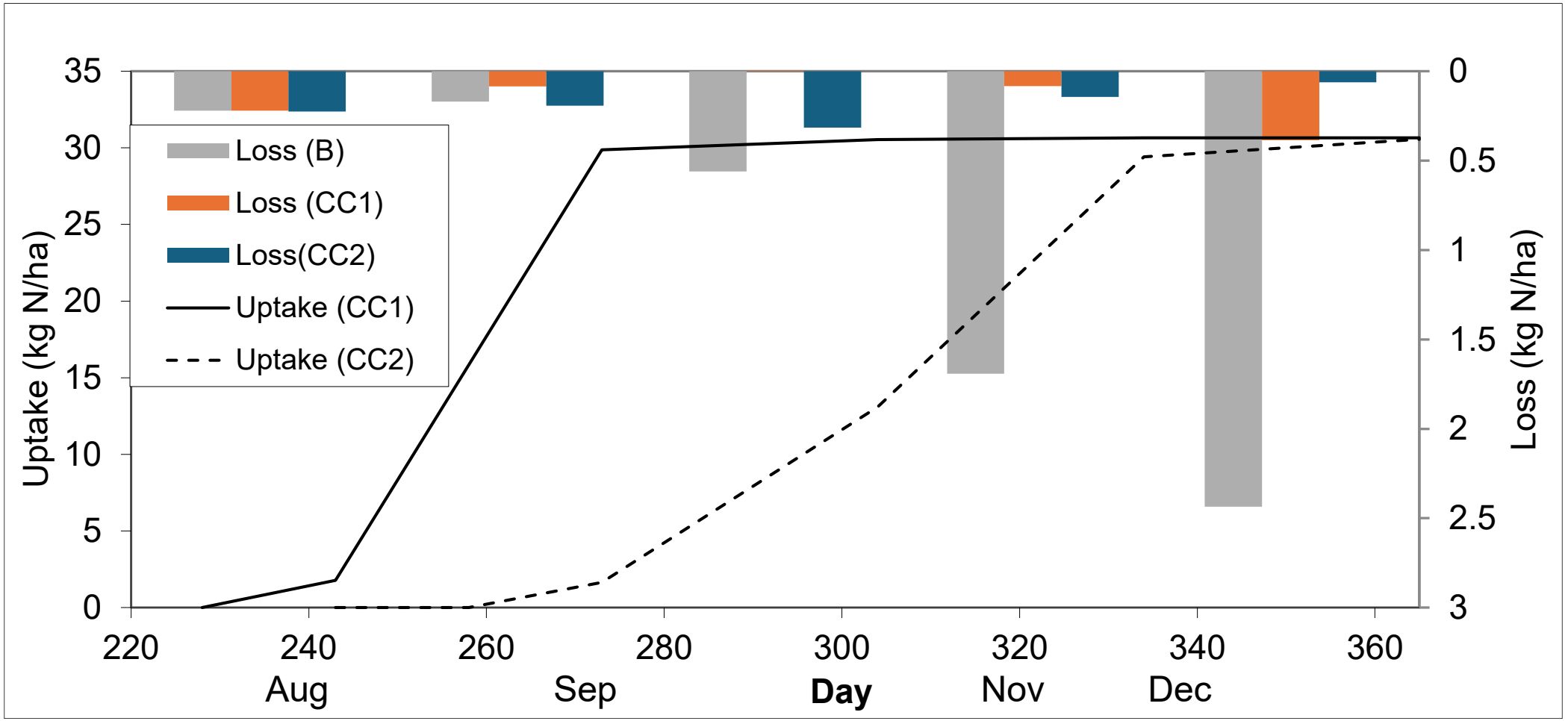
Results: Cover Crop (Plot Scale)

- Crop N Uptake & N loss: Baseline & CC (1=Early/ 2= Late)



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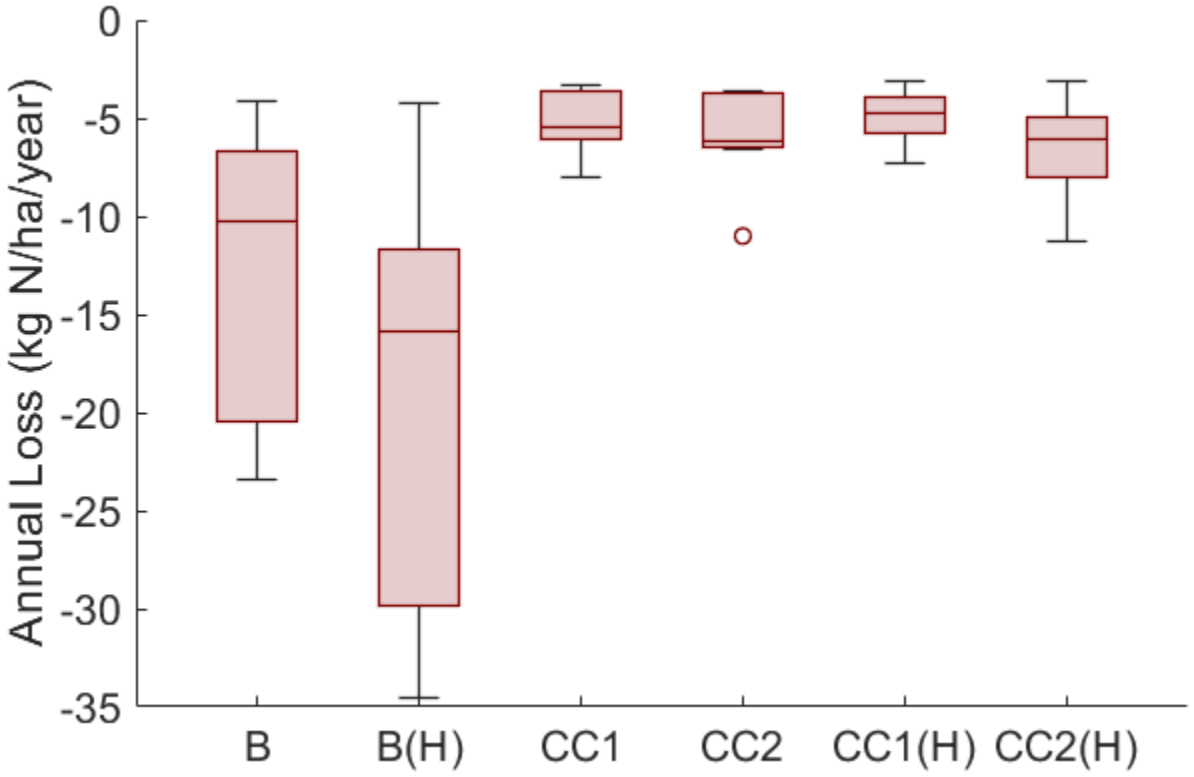
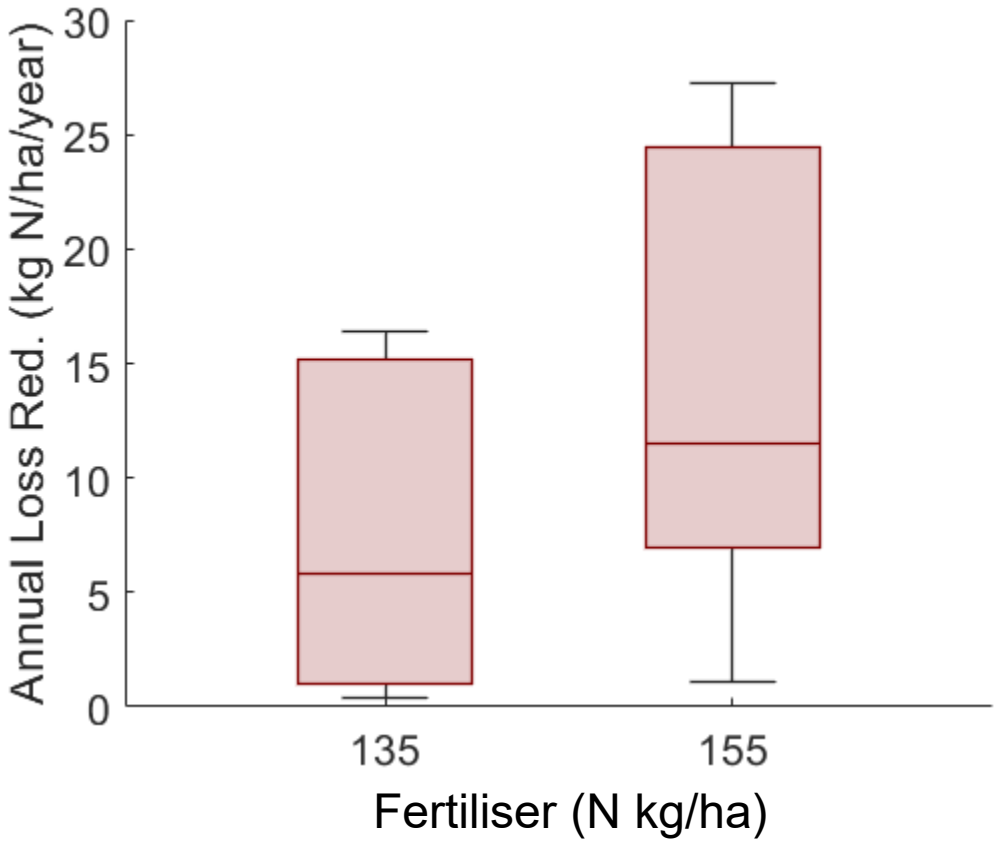
Results: Cover Crop (plot scale)



Annual Losses by Scenario
("B" & "B(H)" = Baseline)



Annual Loss Reduction with CC
(relative to "B" & "B(H)")

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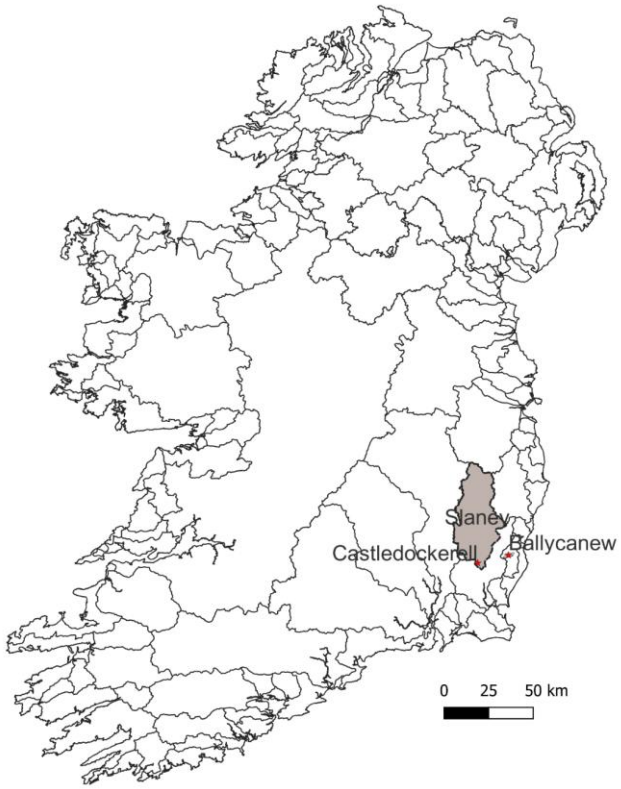
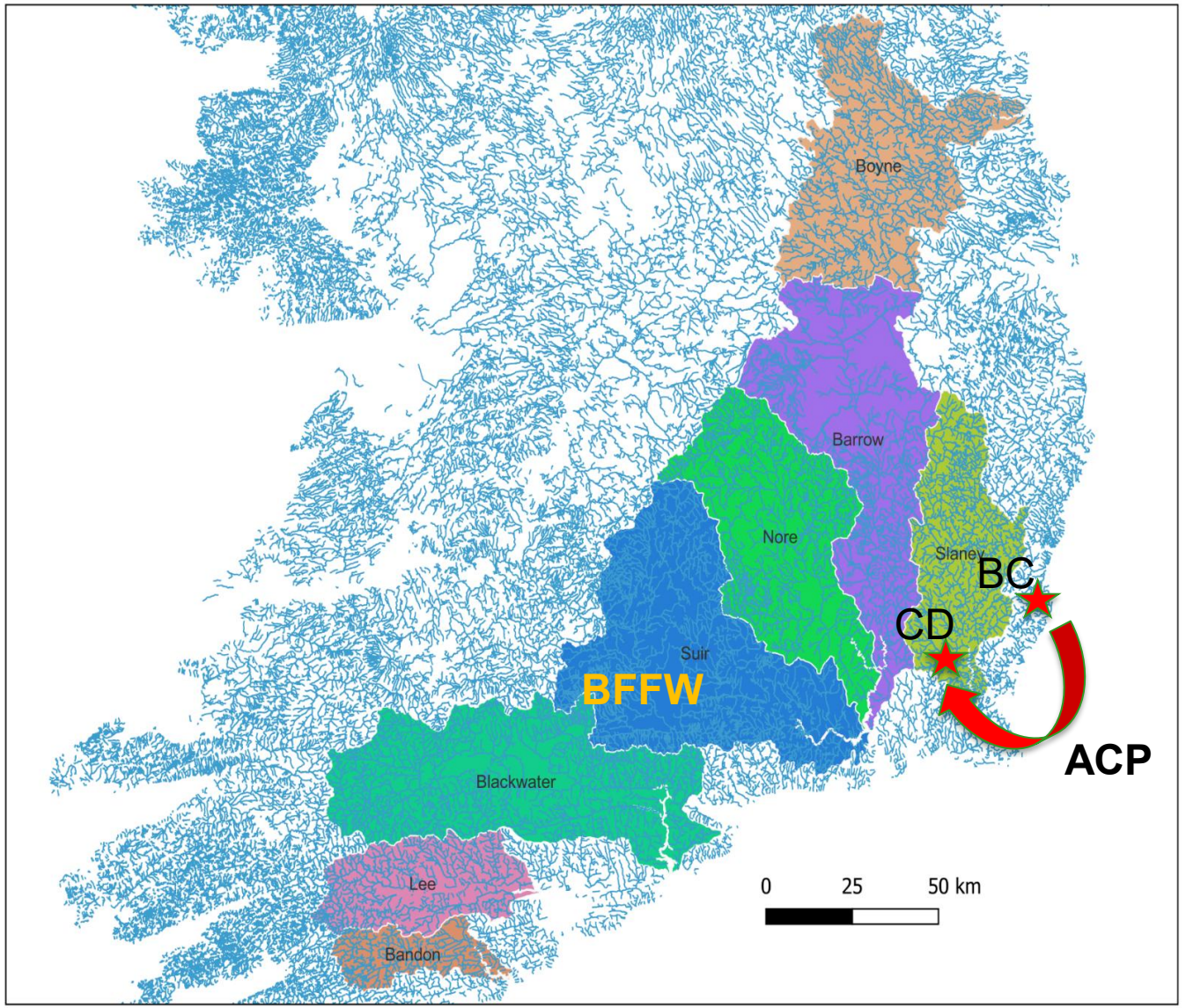
Catchment Modelling Across Scales





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3. Catchment Scale Modelling: ACP

- Same (HYPE) model used to simulate flow and nitrate
- Model calibration used high-res ACP data from Castledockrell
- Model assessed for goodness-of-fit for predicting nitrate loads under baseline conditions
- Scenarios can then be run to investigate mitigation options

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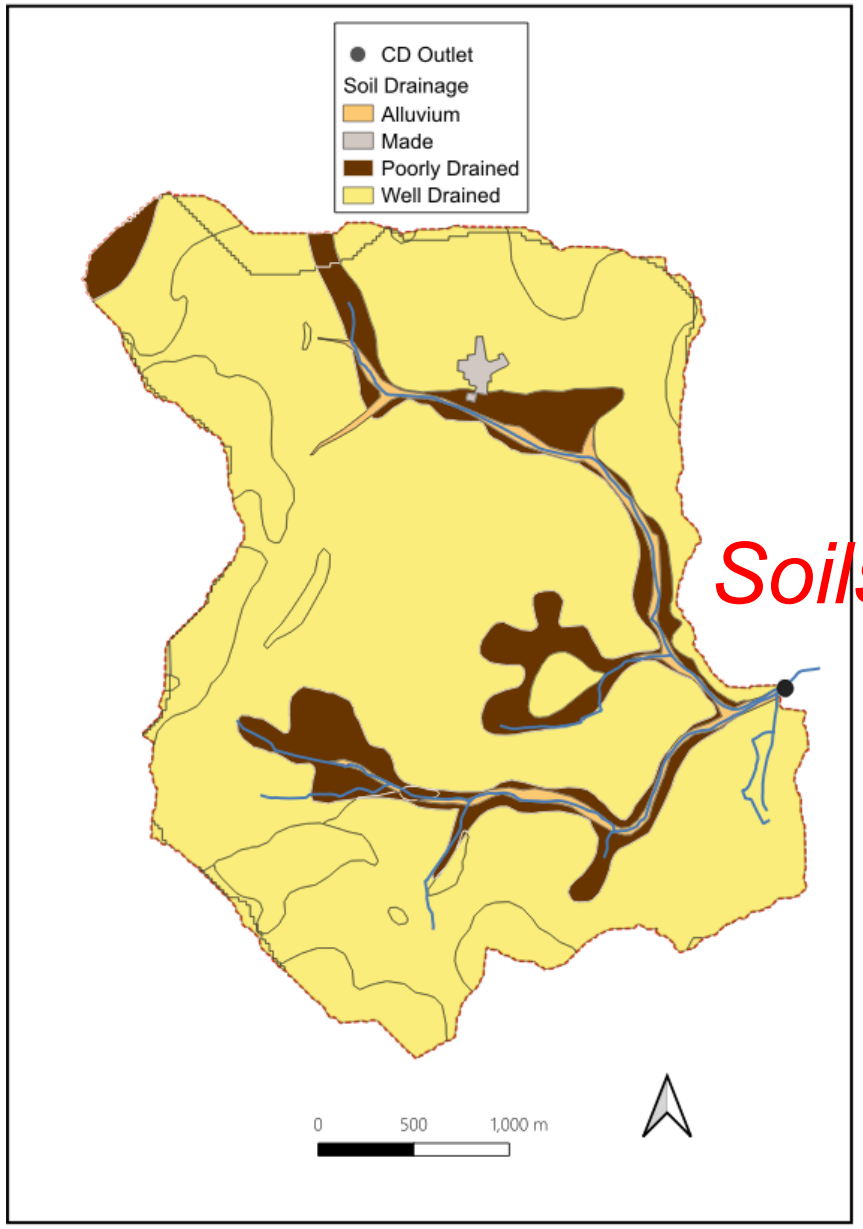
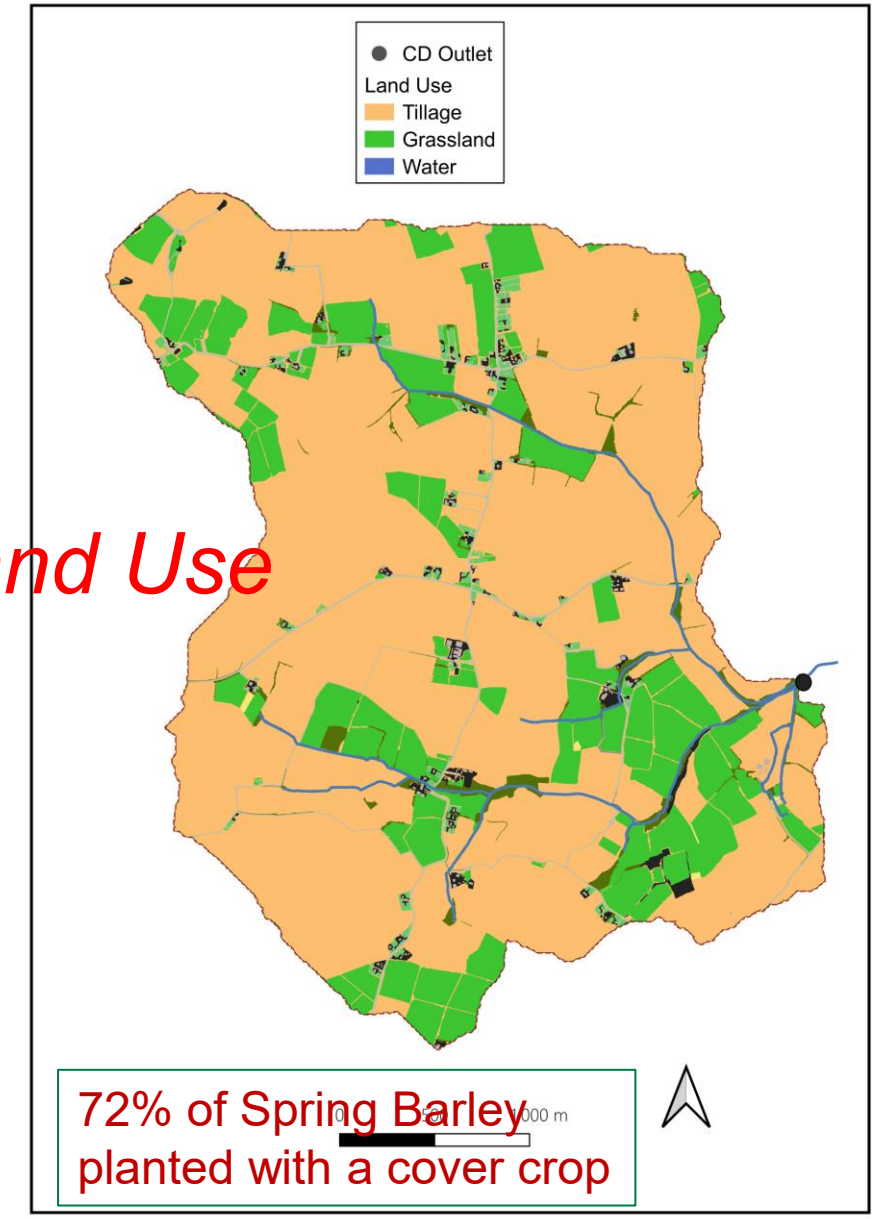
2. Catchment Scale Modelling: Castledockrell

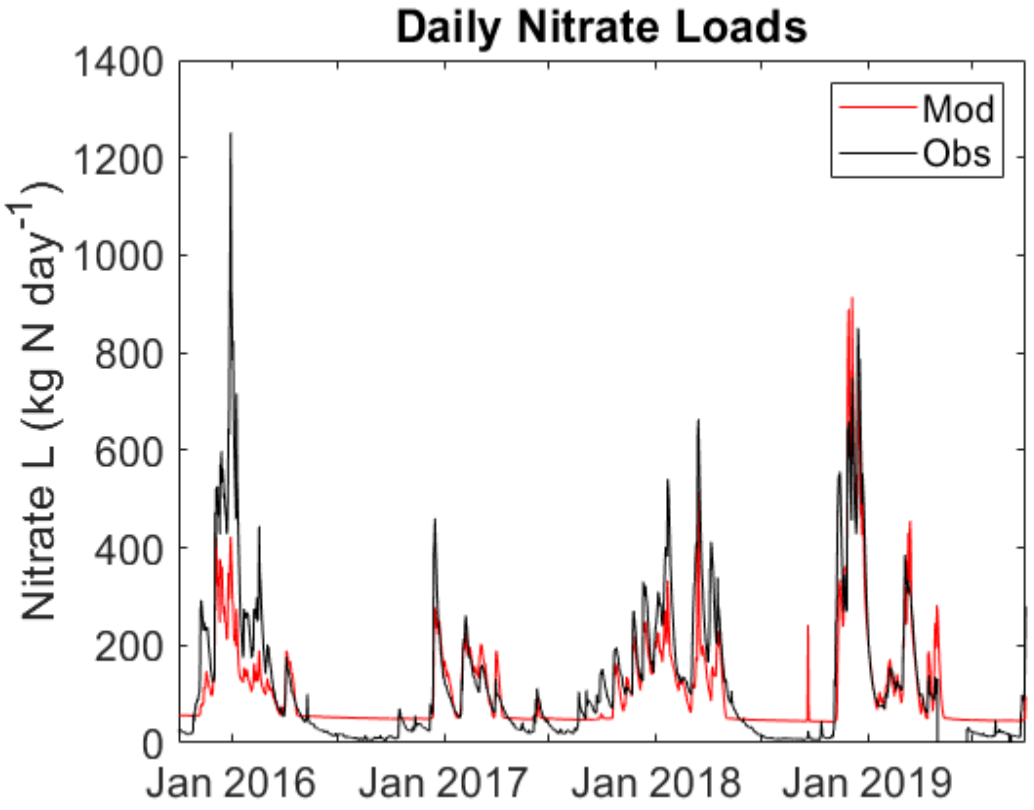


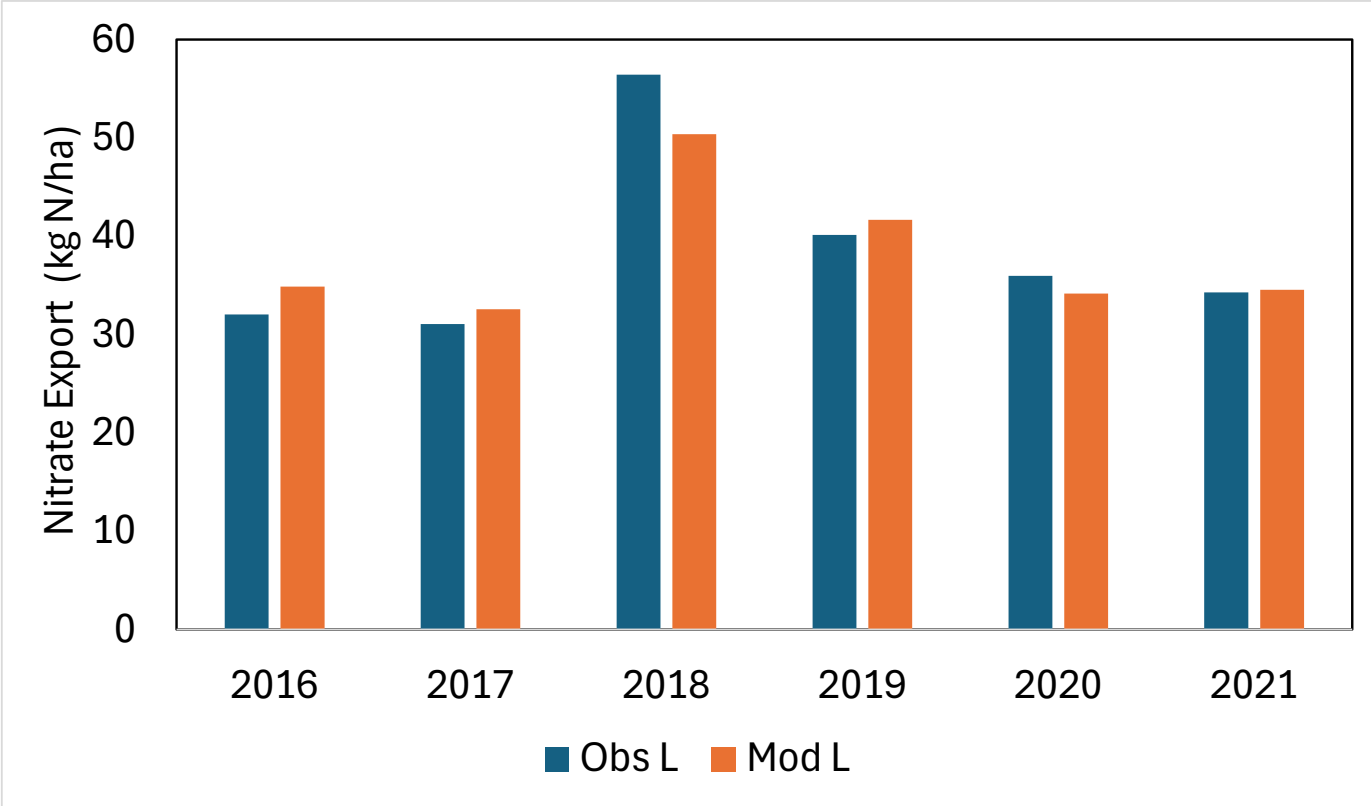
Soils + *Land Use*



72% of Spring Barley planted with a cover crop

Model results: Castledockrell N loads





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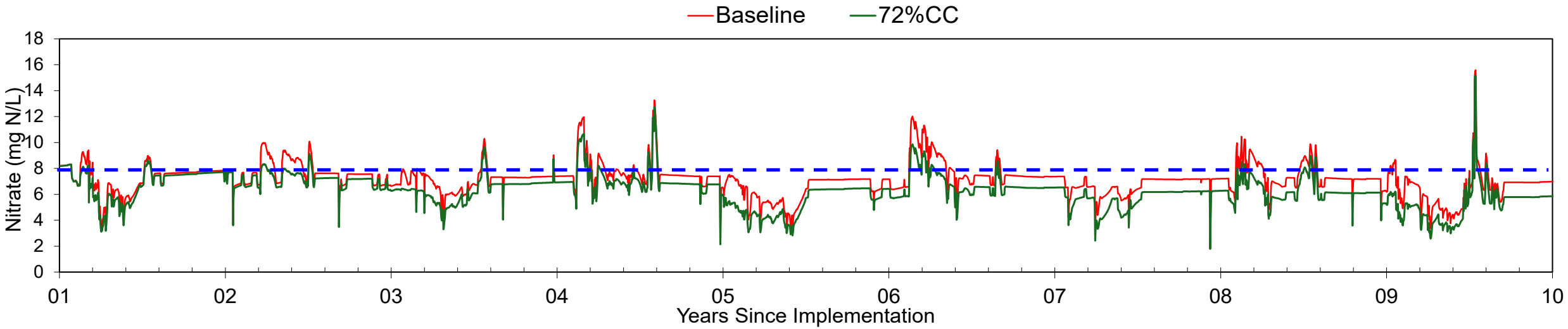
Model results: Cover Crop (CC) Scenario

- Results: ("B" = Baseline) with 9 years of simulation with a cover crop sown each year ("CC") on 72% of spring barley
- Concentrations reduced by up to 14% leaving the catchment(≈ 1 mg N/L)
- Loads reduced by 14% removing 6.2 tonnes N/yr (out of 44)



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4: Slaney Catchment Assessment

- Recent nitrate -N concentrations in the Slaney (> 4 mg N/L) have regularly exceeded the targets set for estuarine waters in the WFD (target NO_3 <= 2.6 mg N/L).
- In context the tillage-dominated area in Slaney is atypical of the country as a whole (≈ 12% spring-sown cereals).
- Load reduction (LR) estimates were calculated based on 2022-24 (EPA)
- The load reduction needed ≈ 1100 t N/year (31%)
- The typical area based N load reductions required range from 15-26 kg N ha/yr, and up to 32 kg N ha/yr from high PIP-N areas
- This is challenging to achieve, Water-EIP in conjunction with Better Farming for Water may provide opportunities to achieve a reduction

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4. Catchment Scale Modelling: Slaney

- Upscaling from research scale to operational catchments used HYPE to simulate flow and nitrate
- Example: scale up ACP Castledockrell > Slaney Catchment, including subcatchments (e.g. Rivers Bann , Boro, Urrin)
- Model parameters transferred from ACP Castledockrell simulations.
- Operational scale work used national data sets (climate, soil type, land use etc).
- Baseline scenario modelled 9 years of cover crops plus “spin up” year (In 2025 > 2100 ha was planted in 1030 km^2)
- Scenario modelling then evaluated mitigation options at the larger scale

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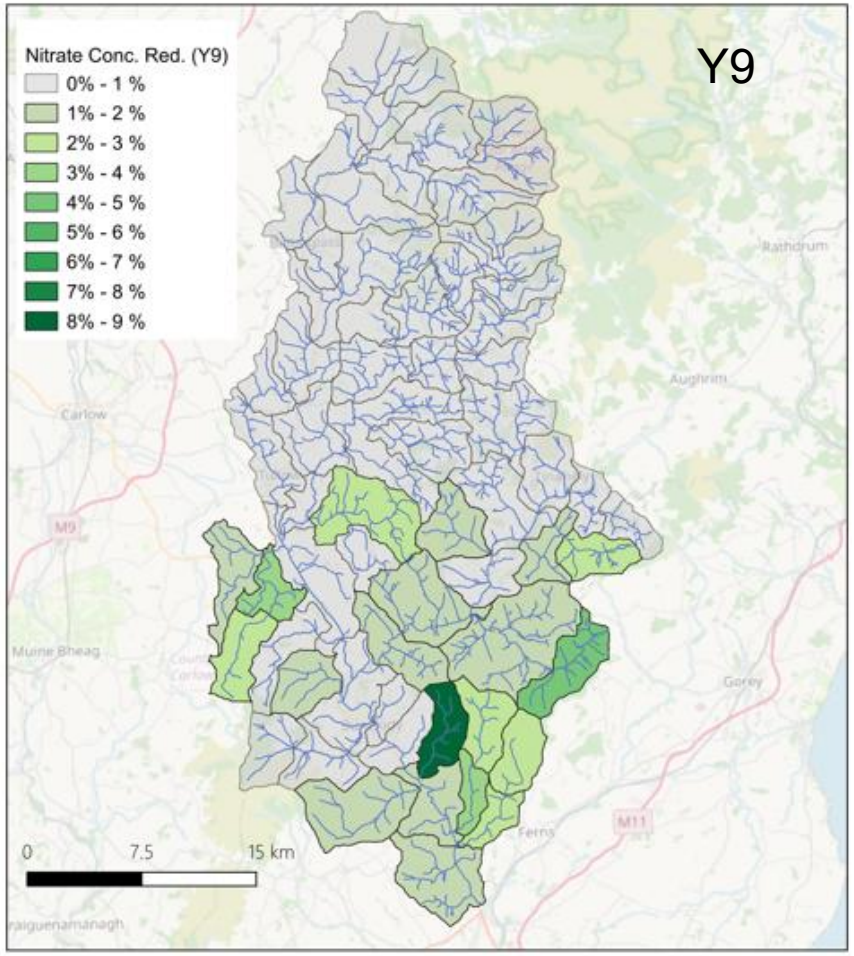
Modelling Results: Slaney Catchment

- Spatial Pattern of NO_3 concentration reductions (Y9)
- Reductions in NO_3 loading over time (across catchment)





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Modelling Results: Slaney Catchment

- **Summary**: In NO_3 concentration terms: A 2% reduction in the lower Slaney river was achieved by Y9 (0.08 mg N/L)
- In LR terms 51 tonnes N (2%) was removed from the river (out of total 2991 tonnes) annually, averaging out at ≈ 0.4 kg N/ha/year across the 1030 km^2 catchment from nearly 2200 ha of cover crops (before spring-sown cereals in Water-EIP 6a)
- From the tillage-dominated lower Slaney subcatchments, LRs were locally higher (around 4 kg N/ha/year)
- In comparison, these results indicate that the cover crops were slightly more effective in Castledockrell, as the area planted in 2025 was larger than in the lower Slaney (72% vs around 40% of SB)

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5 Conclusions

- Simulations using the HYPE Model, evaluated first at plot scale indicated that N losses after cover crops reduced by up to 69%.
- Upscaling extended the model simulations to larger 10km^2 (ACP) catchments, then to the Slaney catchment (> 1000 km^2).
- Cover crops achieved NO_3 Concentration reductions of around 7% in the Bann sub-catchment of the Slaney, and N load reductions were similar.
- Despite reductions in N losses concentrations in the main rivers are still predicted to exceed the “Good” WFD limit after several years of cover crops.
- Cover crops should be adopted as widely as possible in tillage areas for nitrogen load reductions
- Latest research from Teagasc shows that cover crops can also significantly reducing carbon emissions from tillage land

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Thanks for your Attention

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