Land Management:

Role of Land drainage/Water table control in GHG Mitigation

Pat Tuohy *01/05/2020*

Teagasc
Agriculture and Food Development Authority

An Analysis of Abatement Potential of Greenhouse Gas Emissions in Irish Agriculture 2021-2030

Prepared by the Teagasc Greenhouse Gas Working Group

Gary J. Lanigan & Trevor Donnellan (eds.)

Authors:

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June 2018

Teagasc, Oak Park, Carlow

Tithe an Oireachtais
Houses of the Oireachtas

Tuarascáil ón gComhchoiste um Ghníomhú ar son na hAeráide
An tAthrú Aeráide: Comhdhearcadh Traspháirtí don Ghníomhú
Márta 2019

Report of the Joint Committee on Climate Action
Climate Change: A Cross-Party Consensus for Action
March 2019

CLIMATE ACTION PLAN 2019

To Tackle Climate Breakdown

Rialtas na hÉireann
Government of Ireland

Role of Land Drainage/ Water table control

- **Teagasc GHG Working Group-MACC**
  - **Measure 10**: Draining Wet *Mineral Soils*
    - » ***Measure 7****: Extended Grazing*
  - **Measure 17**: Water Table Manipulation of *Organic Soils*
    - » Also referred to as Rewetting

Mineral or organic soils?

- **Mineral soils** are derived from mineral matter-sand, silt, clay (+ larger particles)
  - Little organic matter (< 10%)

Mineral or organic soils?

Organic

- **Peats** possess an organic layer with at least 20% Organic Carbon (OC) and a minimum thickness of 40 cm.

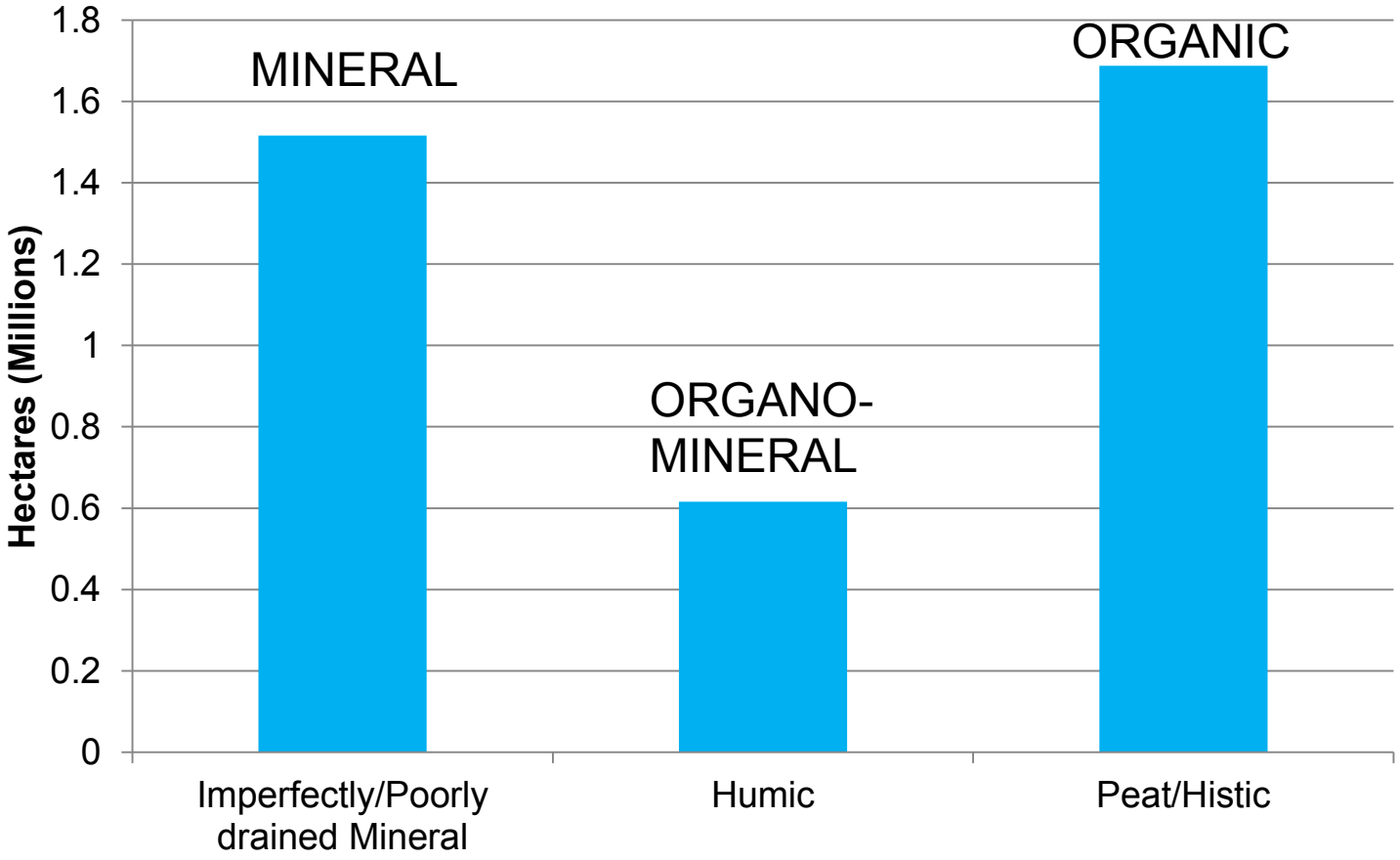
- **Histic soils** have a peaty (>20% OC) (O) horizon that has a thickness of 7.5 or more

Mineral or organic soils?

Organo/mineral

- **Humic soils** contain an A horizon with significantly more organic matter, than mineral matter.
- Minimum thickness is 7.5 cm and OC content is lower (depending on the clay content)

Mineral or Organic soils?



Mapped within Irish Soil Information System

Current work using satellite imagery to refine further

Role of Land Drainage

- Measure 10: Draining Wet Mineral soils
- *"one-third of Irish land area can be classified as poorly draining…*Assuming that one-third of this area (i.e. 10% of total grassland area) was drained by 2030*"*

  - Nature of Measure: Reducing N_2O Emissions
  - Cost € per t/CO_2 Eq: €16.2
  - Mitigation Mt CO_2 Eq: 0.197
  - Cost €M: €6.1

Role of Land Drainage

- Measure 7: Extended Grazing
- *"production systems that either require improved drainage or could benefit from on-off gra*zing…The measure was assessed on 20% of grassland area*"*

- Nature of Measure: Production Efficiency
- Cost € per t/CO_2 Eq: -€96
- Mitigation Mt CO_2 Eq: 0.066
- Cost €M: -€6.3

MACC Curve

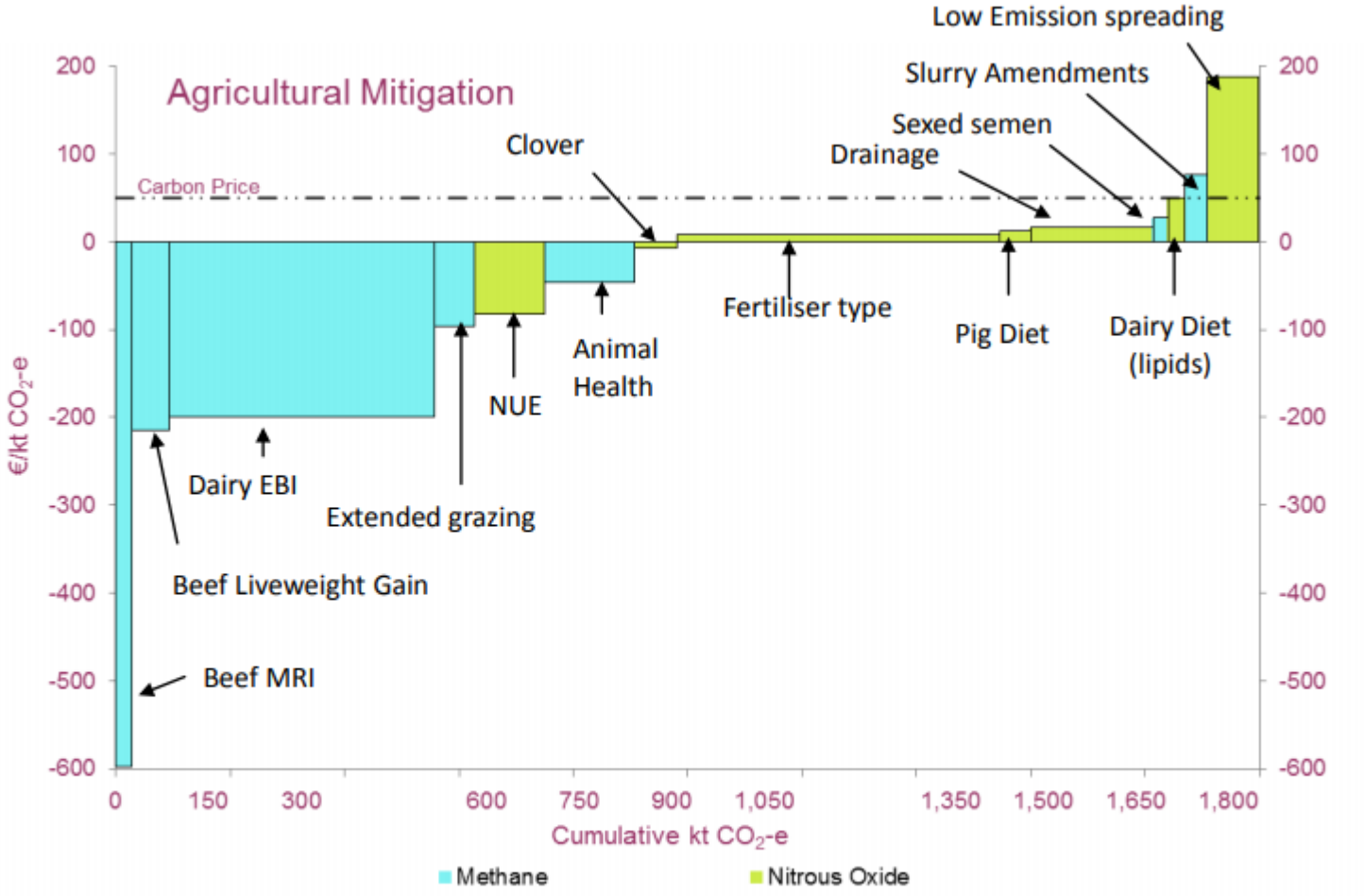
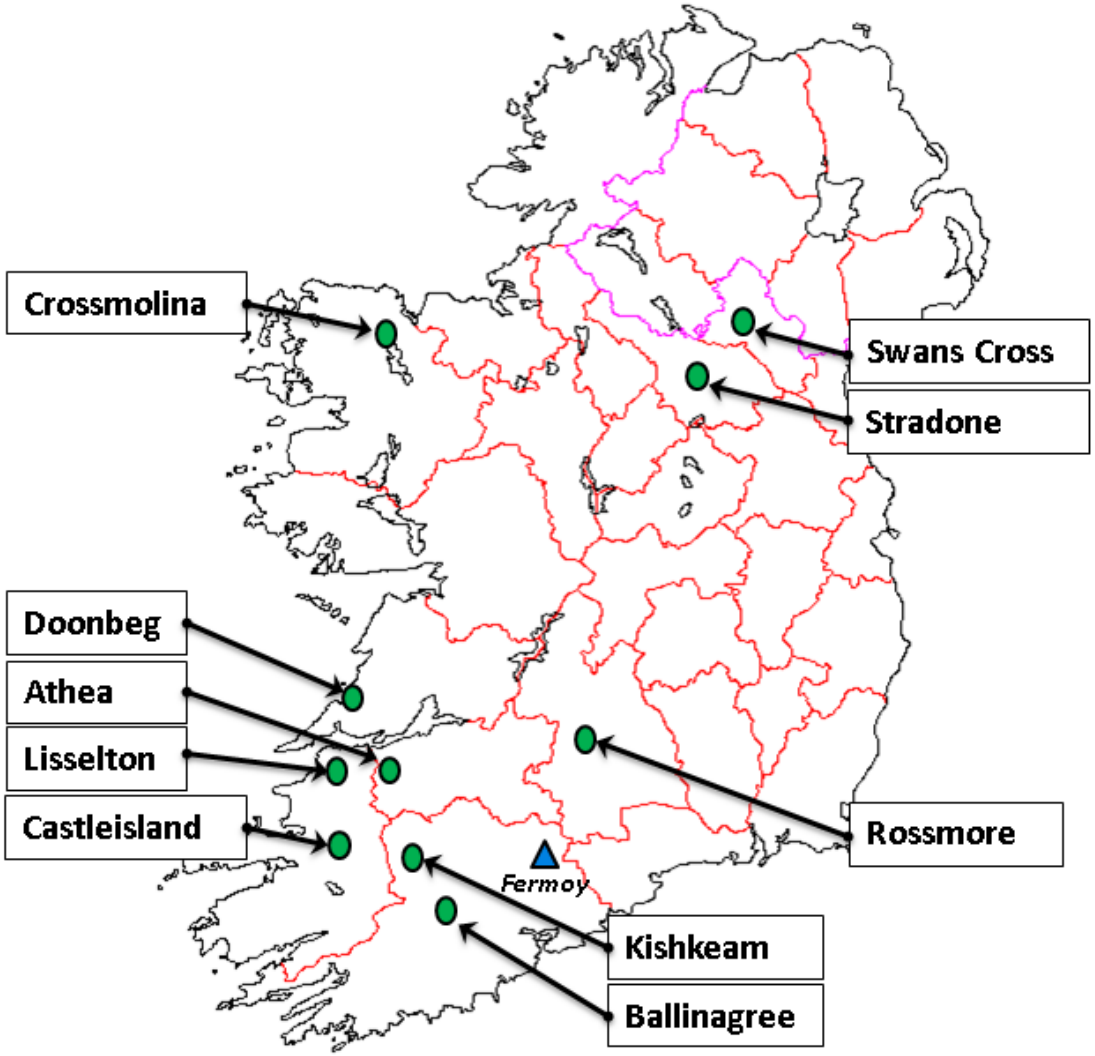


Figure 3.1: Marginal Abatement Cost Curve for agriculture for 2021-2030 (methane and nitrous oxide abatement). Values are based on linear uptake of measures between the years 2021-2030 and represent the mean yearly abatement over this period. Dashed line indicates Carbon

Heavy Soils Programme Farms



Types of drainage system

- The depth and type of drain to be installed depends entirely on the interpretation soil characteristics.
- Two principle types are distinguished:
  - **Groundwater drainage system:** A network of deeply installed piped drains exploiting permeable layers
  - **Shallow Drainage system:** Where soil is heavy and infiltration of water is impeded at all depths and permeability needs to be improved

Groundwater Drainage System

- **A Groundwater drainage system is a network of field drains collecting groundwater which can move through soil layers of high permeability**
- They work by exploiting the natural capacity for movement of water at a certain depth in certain soils
- By “tapping” into this natural capacity for water movement the system works by lowering the watertable and reducing the amount of water stored in the soil

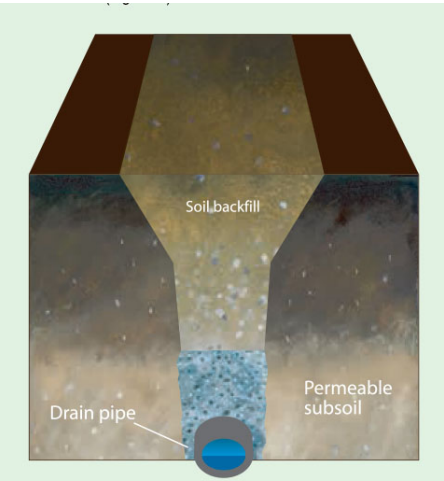
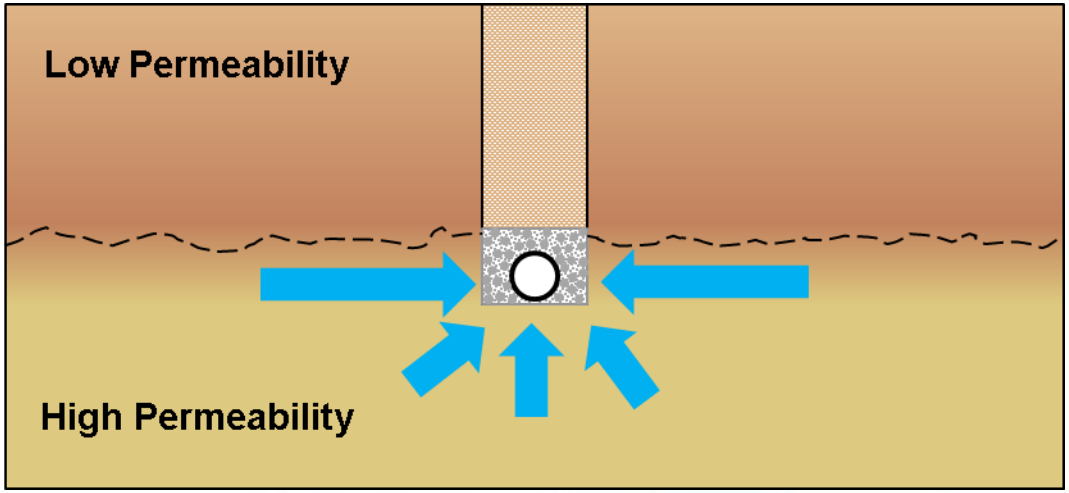


Figure 1. Connection with permeable layer.



Shallow Drainage System

- **A shallow drainage system is a network of field drains in tandem with surface disruption techniques which promote water infiltration and drainage**

- Used where soil permeability is low at all depths and aims to introduce new pathways for water movement in the soil

- Methods include: Mole drainage, gravel mole drainage, sub-soiling (pan busting) and land forming

Land Drainage Research/Design

Drainage System monitoring

Met. Data
Drain Discharge
Watertable depth
Soil moisture

Agricultural Water Management 169 (2016) 129–139

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Runoff and subsurface drain response from mole and gravel mole drainage across episodic rainfall events

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MODELING PERFORMANCE OF A TILE DRAINAGE SYSTEM INCORPORATING MOLE DRAINAGE

advances in drainage

P. Tuohy, J. O'Loughlin, O. Fenton

ABSTRACT. *Mole drain performance is known to vary temporally and spatially due to variations in soil properties, instal-*

Agricultural Water Management 192 (2017) 115–125

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Field soil and ditch sediment phosphorus dynamics from two artificially drained fields on poorly drained soils

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Agricultural Water Management 210 (2018) 96–107

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

The performance and behavior of land drainage systems and their impact on field scale hydrology in an increasingly volatile climate

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ARTICLE INFO

Keywords:
Flow response
Drain discharge
Hydrograph
Groundwater
Climate change

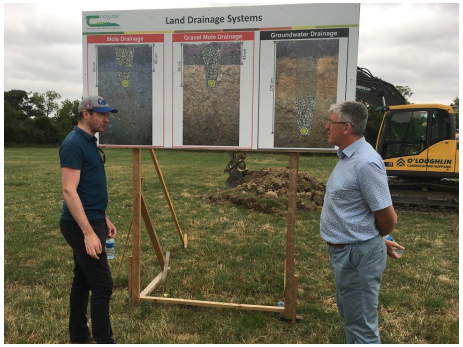
ABSTRACT

Escalations in rainfall intensity, both in terms of volume and frequency are increasing the volatility associated with grassland agriculture on poorly drained soils. The principal mechanism of reducing this volatility is by means of land drainage; however the efficacy of drainage systems is widely variable and has not been fully quantified. The excavation of soil test pits and a corresponding examination of the soil profile enables bespoke land drainage system design. Across heterogeneous soil-scapes this leads to variations to both groundwater and shallow drainage designs. In the present study we examine the performances of 9 site-specific drainage systems (5 groundwater and 4 shallow drainage designs), during a high rainfall period (01/10/2015-31/05/2016) in terms of response times (start, peak and lag times), discharge characteristics (peak flow rate, total discharge, flashiness index, discharge hydrographs) and water table control capacity. Response times were not affected by drainage system or drainage design type, showing similar responses despite variation in soil types where appropriate drainage systems are installed. Total discharge (1098.4 vs. 189.6 m^3/ha) and peak flow rate (51.0 vs. 16.8 m^3/ha/h) were significantly higher in groundwater designs relative to shallow alternatives. Groundwater drainage designs generally maintained a deeper mean water table depth (0.82 m) than shallow designs (0.53 m) during the study period. The functional capacity of each land drainage system was inherently different. The comparison of such systems highlights contrasting behaviors of individual drainage systems and drainage design types, which is dictated largely by the hydraulic capacity of the soil within their catchment and their connectivity to different water bodies (groundwater versus perched water). All systems reduced the overall period of waterlogging and improved the conditions for both the production and utilization of the grasslands they drain, although temporal variations in agronomic parameters are likely to be more pronounced in shallow designs.

- *"All systems are shown to reduce the overall period of waterlogging and improve surface conditions"*

teagasc
AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY

Dissemination, Extension, Training



Winning the war on water

We travel to Macroom to find out how good drainage has transformed Con and Neilie Lehane's farm

Darragh McCullough PUBLISHED

IFM
FORAGE AND NUTRITION Guide 2016

Pat Tuohy, Owen Fenton and James O' Loughlin, Teagasc

LAND DRAINAGE GUIDELINES

Approximately 49.5% (3.4 million hectares) of the total land area of Ireland is classified as 'marginal land', which is affected by natural limitations related to its soil, topography, relief and climate. The major limitation is its poor drainage status, and much is in need of artificial drainage if its productivity is to be improved. In wet years poorly drained soils may never dry out as persistent rainfall maintains high soil moisture content

Grass yields are limited due to the adverse effect of excess water and a lack of air at rooting depth, which limits plant respiration and growth. In cases of prolonged water-logging, plants will eventually die due to a lack of oxygen in the root zone. Furthermore, waterlogged soils are impassable to machinery and livestock traffic for long periods, due to high soil moisture content and reduced soil strength. This reduces the number of grazing days and hinders silage harvesting, thus introducing higher

- Low permeability in the subsoil (or a layer of the subsoil);
- High water table due to low-lying position and poor/poorly-maintained outfall;
- Upward movement of water from seepage and springs.

OBJECTIVES OF LAND DRAINAGE

To achieve effective drainage, the works will have to

Role of Land Drainage

- Measure 17: Water table manipulation of organic soils
- *"if drainage was stopped completely and natural water table conditions were restored (on) 40,000 Ha of rewetted grassland"*

  - Nature of Measure: Rewetting of 40,000 Ha of Organic grassland soils
  - Cost € per t/CO_2 Eq: €10.9
  - Mitigation Mt CO_2 Eq: 0.44
  - Cost €M: €4.84

MACC Curve

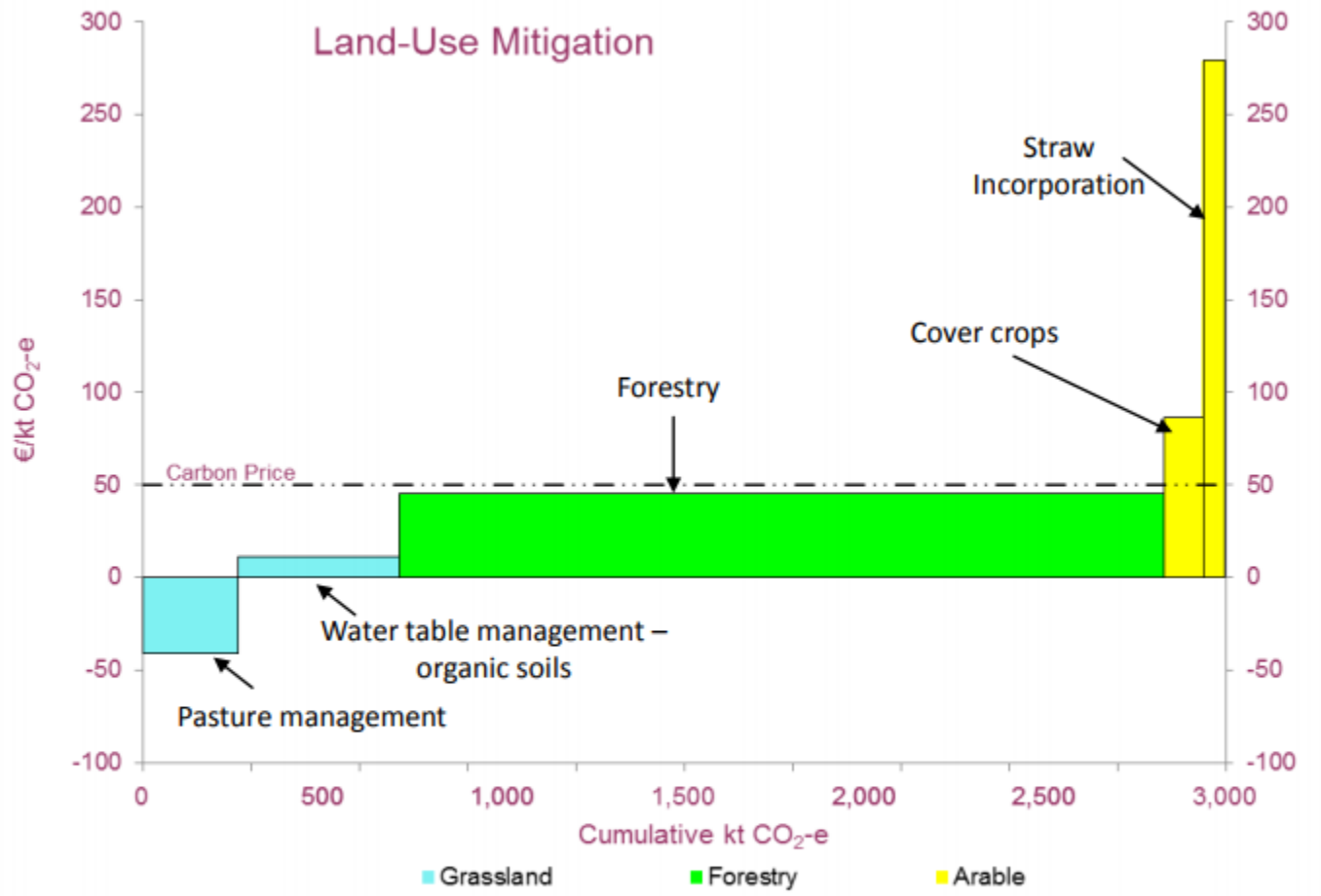
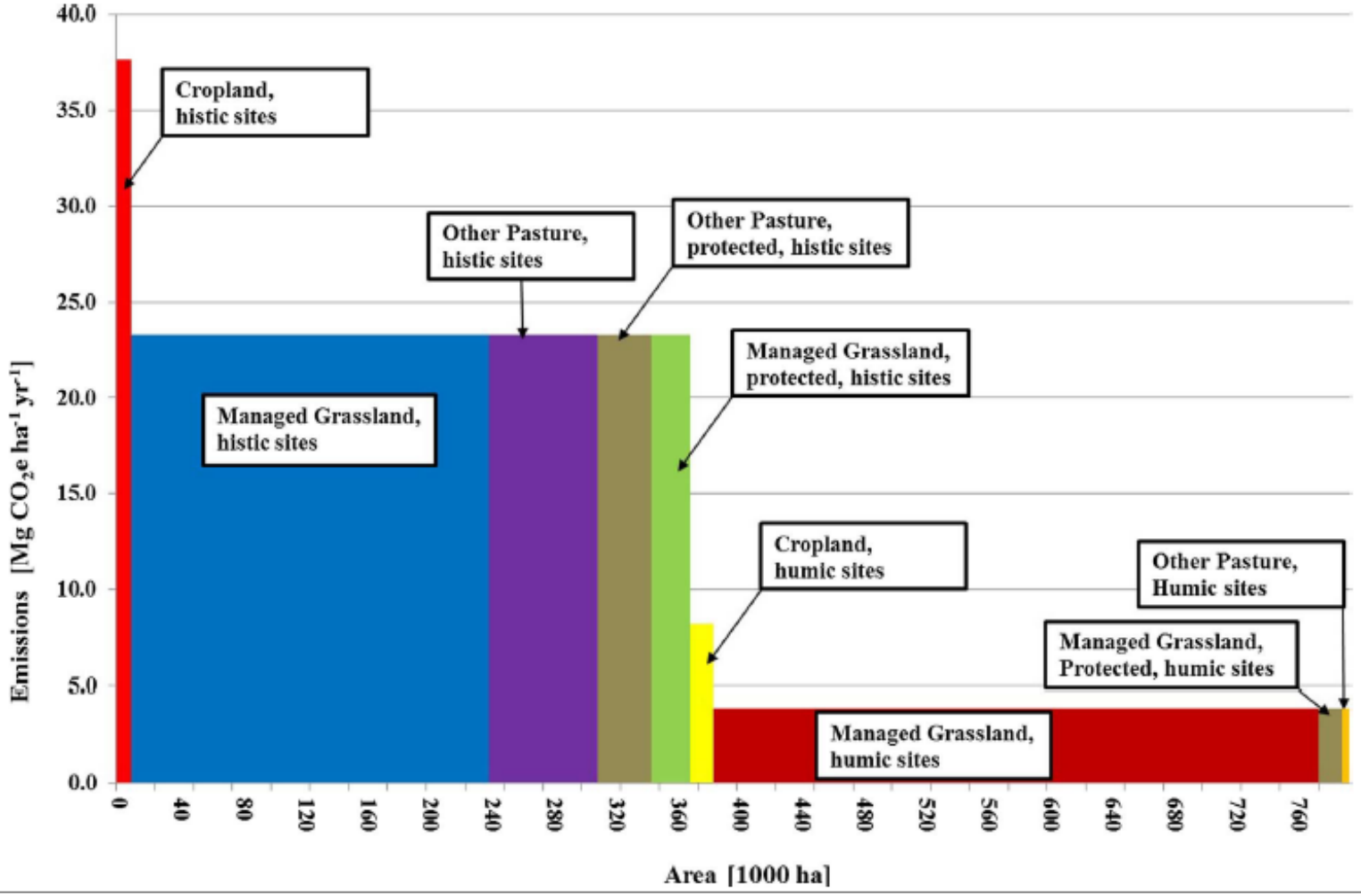


Figure 3.2: Marginal Abatement Cost Curve for agriculture for 2021-2030 (carbon sequestration associated with land management and land-use change). Values are based on linear uptake of measures between 2021-2030. Dashed line indicates Carbon cost of €50 per tonne CO_2.

GHG emissions from Carbon rich soils in Ireland drained for agriculture



Paul et al., 2018 *"modelling was based on an extreme drainage situation with a very high water table before drainage and a very low water table afterwards. Less extreme hydrological situations may result in lower emissions."*

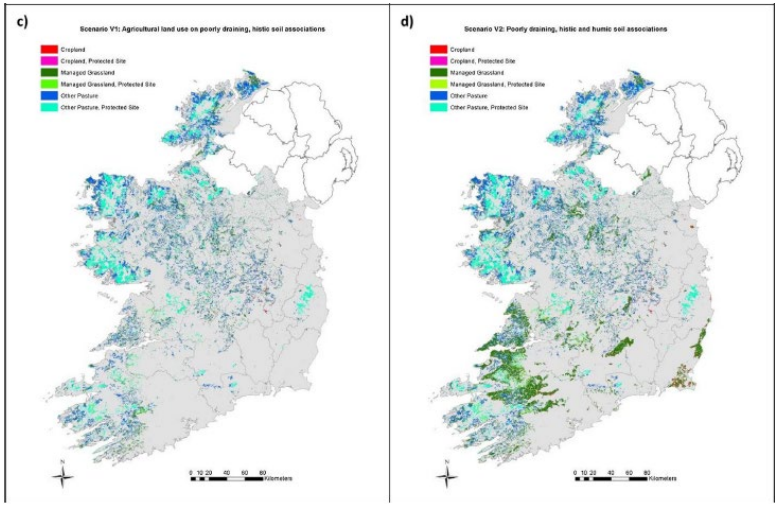
Peat-Land Area

- **Characterisation of peat areas under agricultural management are required to identify suitable areas for rewetting**

Peatland category	*hectares*
Natural peatlands	269,270[a]
Cutover peatlands (affected by domestic turf-cutting)	612,380[a]
Afforested peatland	301,700[b]
Farmed peatland (grassland and cropland)	295,000[c]
Industrial cutaway peatlands	70,000[d]
Rehabilitated cutaway	18,000

(O' Sullivan et al. 2018)

- "The (assumed) total area of drained (peat)/histic soils was 370,000 ha (under agriculture)" **(GHG-MACC)**"



Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Assessing the role of artificially drained agricultural land for climate change mitigation in Ireland

Carsten Paul[a,b,*], Réamonn Fealy[c], Owen Fenton[a], Gary Lanigan[a], Lilian O'Sullivan[a], Rogier P.O. Schulte[a,d]

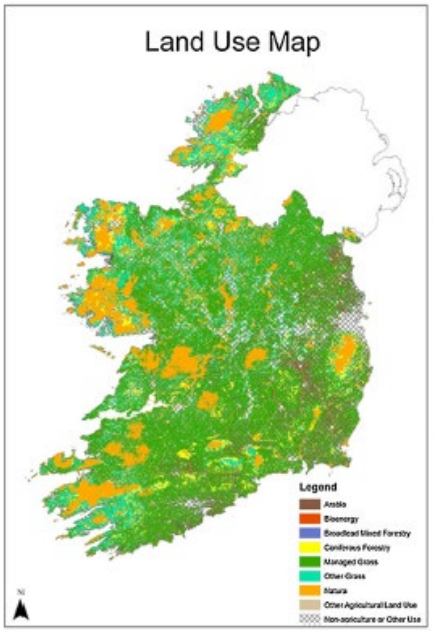
Contents lists available at ScienceDirect

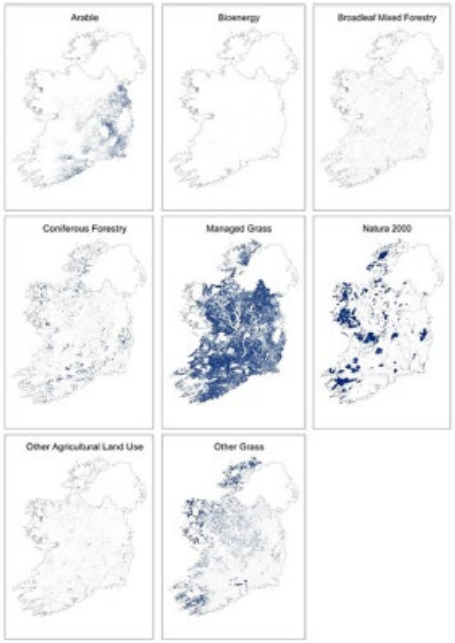
Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Functional Land Management for managing soil functions: A case-study of the trade-off between primary productivity and carbon storage in response to the intervention of drainage systems in Ireland

L. O'Sullivan[a,b], R.E. Creamer[c], R. Fealy[d], G. Lanigan[b], I. Simo[c], O. Fenton[b], J. Carfrae[e], R.P.O. Schulte[c,*]

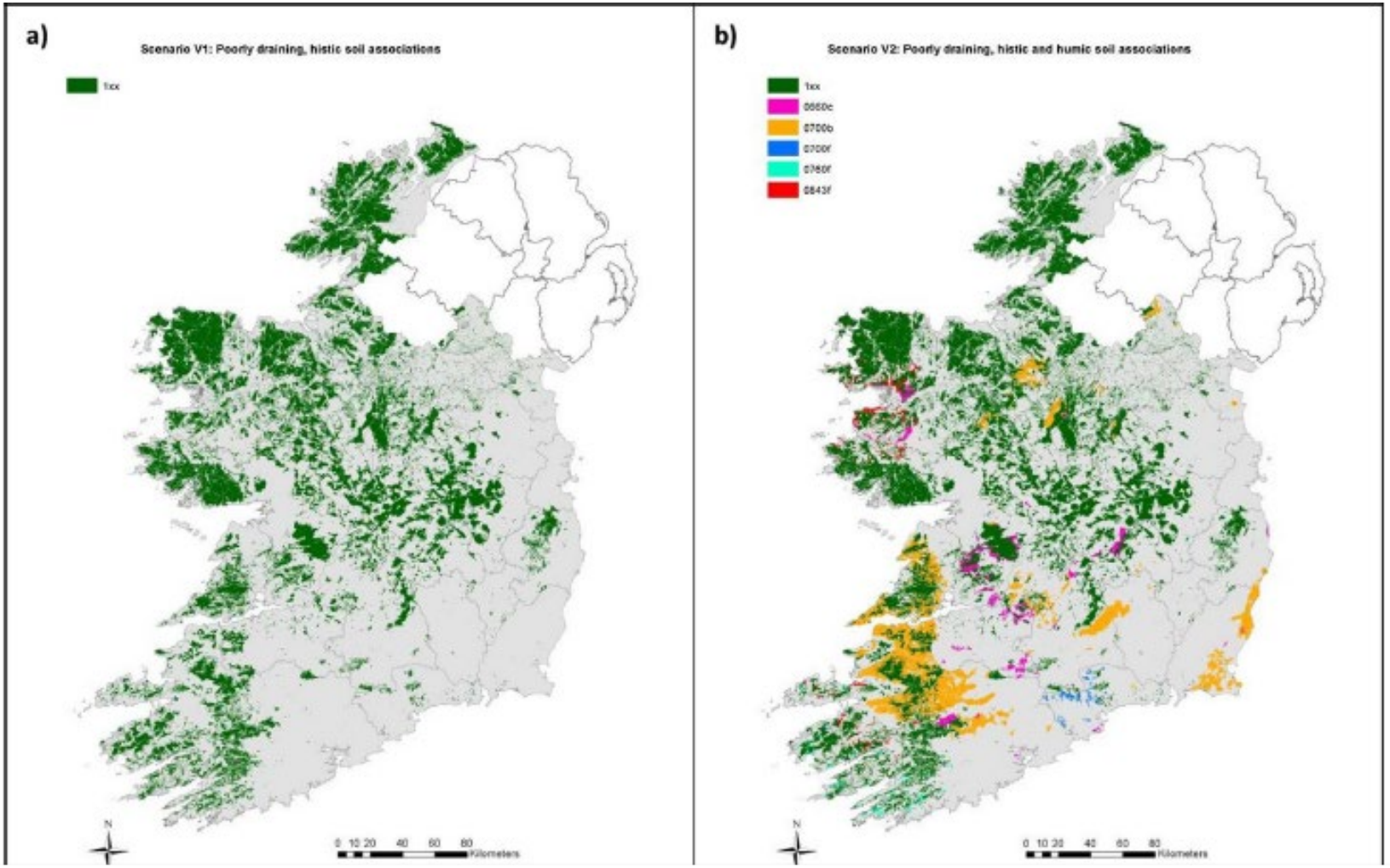




Produced maps of:

- Land Use
- Soil drainage class

Agriculture and Food Development Authority



BUT ALREADY ARTIFICALLY DRAINED subgroups predicted:

370,000 ha of histic soils drained (assumed)
426,000 ha of humic soils drained (assumed)

Paul et al., 2018

Summary

- The drainage of mineral soils is positive (in terms of GHG emissions) and also contributes towards extended grazing

- Annual emissions from drained "Carbon-Rich" soils are **estimated** up to:
  - 8.7 Tg CO_2e from histic soils **(Organic)**
  - 1.8 Tg CO_2e from humic soils **(Organo-Mineral)**

1 Tg (Teragram) = 1 million metric tonnes

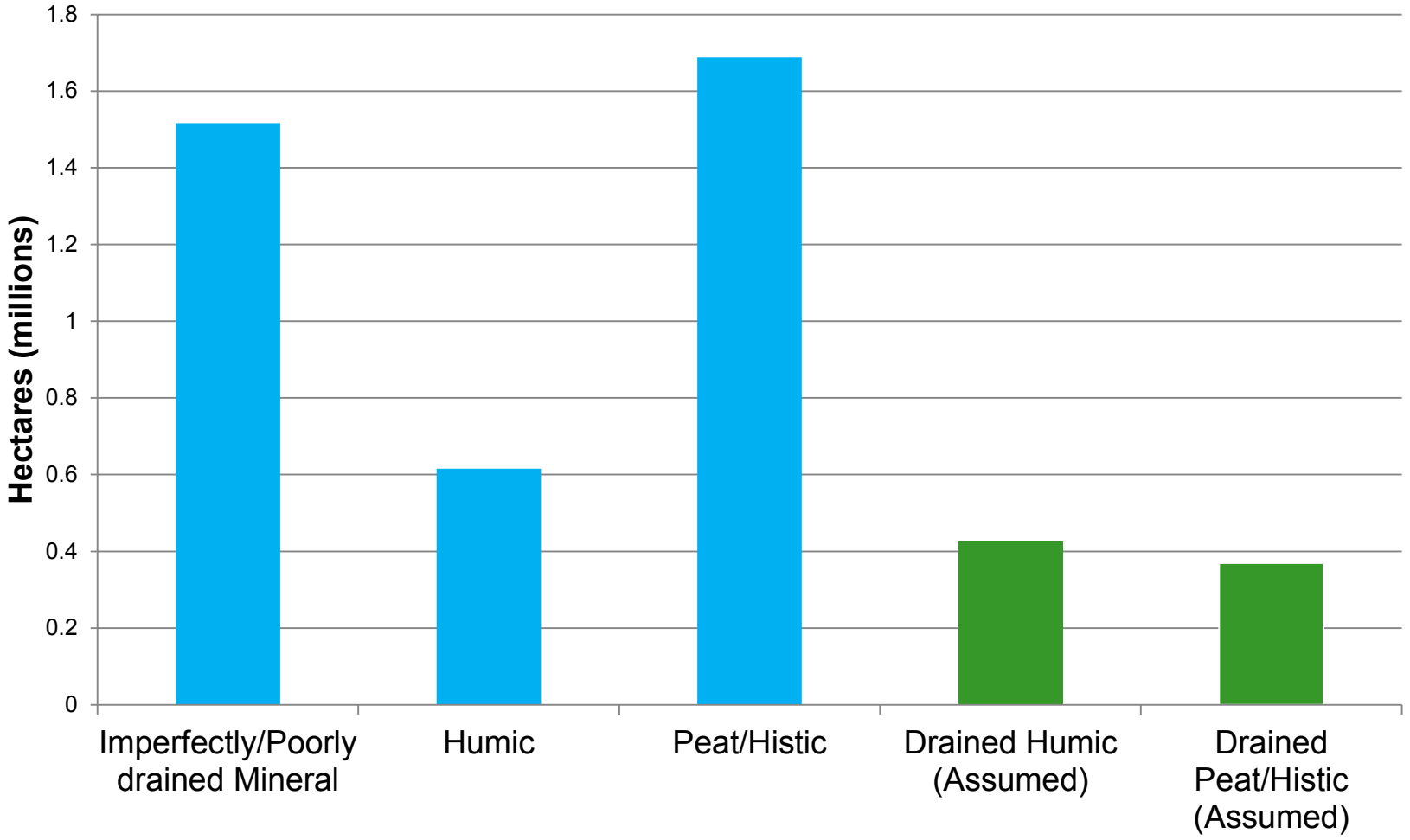
- National policy - recognizes the importance of preserving **organic (histic) and humic soils**' carbon stock, but requires data that is not readily available.

- We do not know the area of drained organic soils in Ireland

- We do not know how much has already reverted to **"undrained"** conditions

- **Further research will explore the site suitability and cost effectiveness, as well as trade-offs and co-benefits of rewetting.**

Summary



Agriculture and Food Development Authority

Questions?

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