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Assessment of Agricultural Activity on Drained Organic Soils

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Rialtas na hÉireann
Government of Ireland

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Assessment of Agricultural Activity on Drained Organic Soils

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EPA Research Report

Prepared for the Environmental Protection Agency

by

University of Limerick

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Executive Summary

Peatlands cover 20% of the Irish landscape and store between 53% and 61% of total soil carbon stocks. In total, 80% of peatlands have been drained for peat cutting, afforestation and conversion to agricultural use. As a signatory to the United Nations Framework Convention on Climate Change, Ireland is required to make an annual inventory of greenhouse gas emissions and sinks in the agricultural sector. Although guidelines on the compilation of such inventories are provided by the Intergovernmental Panel on Climate Change, reporting at higher tiers requires the collection of national specific information, including the accuracy of inventories. Total land area (including accuracy estimates) and national emission factors are lacking for agricultural activity on drained organic soils.

This assessment estimated the total land area of drained organic soil under cultivation for arable crops, including an accuracy assessment, and subsequently estimated annual carbon dioxide and nitrous oxide emissions from cultivated organic soils.

A map overlay analysis using existing geographic data on peat habitats and agricultural activities was initially used to locate drained organic (peat) soils under cultivation. The map overlay analysis showed that 3688 ha of land under cultivation for arable crops overlapped land classified as organic soils. A probability sampling method and a ground truthing technique were chosen to assess the accuracy of the overlay. The focus of this task was on the accuracy of the peat data. The agricultural data were considered to be quite robust; therefore, they were used to limit the area from which the sample would be drawn, i.e. the target area. Sample sites were randomly chosen on the overlay within (1) areas classified as peat habitats, or (2) areas within 100 m surrounding (1), or (3) areas classified as peat during the map overlay analysis. In total, 69 sites were assessed and soil samples were collected, analysed and compared with the overlay map classification. Subsequently, an error matrix was constructed from which accuracy information and an error-adjusted area estimate for drained organic soils under cultivation for arable crops were calculated.

The total area of cultivated organic soils was estimated (after being adjusted to account for classification error in the overlay) to be 1235 ± 784 ha. The overall accuracy of the overlay was 77%. There was a high producer's accuracy (84%) and a low user's accuracy (28%) for the peat category. This was because 18 of the 25 sites classified as having organic soil on the overlay map were found to have mineral soil when sampled. Only one site of the 44 classified as having mineral soil was found to have organic soil when sampled.

Future policies will require the identification of strategies to reduce greenhouse gas emissions and enhance carbon sinks. A vital prerequisite to this will be a clear understanding of the nature and extent of agricultural activity on organic soils and this project contributes to the closure of this information gap.

1 Introduction

Peatlands are significant in terms of carbon (C) storage (Gorham, 1991; Byrne *et al*., 2004) and biosphere–atmosphere exchange of greenhouse gases (GHGs) (Strack, 2008). Although pristine peatlands are generally considered to be sinks for carbon dioxide (CO_2) (e.g. Laine *et al*., 2007a) and sources of methane (CH_4) (e.g. Laine *et al*., 2007b), drainage and land use change greatly alters this dynamic. Lowering the water table leads to an increase in peat decomposition and associated soil CO_2 emissions (Minkkinen *et al*., 2008; Oleszczuk *et al*., 2008). CH_4 emissions usually cease after drainage (von Arnold *et al*., 2005) whereas nitrous oxide (N_2O) emissions may increase, particularly on fertile sites (Martikainen *et al*., 1993). Furthermore, disturbance is known to increase C losses in drainage waters (Yallop and Clutterbuck, 2009).

In Ireland, peatlands cover 20% (Connolly and Holden, 2009) of the landscape and store between 53% (Tomlinson, 2005) and 61% (Xu *et al*., 2011) of total soil C stocks. Anthropogenic disturbance has greatly impacted these peatlands, with Renou-Wilson *et al*. (2011) estimating that some 80% of Irish peatlands have been disturbed. This disturbance includes activities such as peat cutting, afforestation and conversion to agricultural use.

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), Ireland is required to make an annual inventory of GHG emissions and sinks in the agricultural sector. Although guidelines on the compilation of such inventories are provided by the Intergovernmental Panel on Climate Change (IPCC, 2006), accurately reporting at higher tiers requires the collection of national specific information. Currently, these data are lacking for agricultural activity on organic (or peat) soils.

What makes these soils so significant is the potential for GHG emissions and the prospective emissions reduction through changes in management. For example, in Table 2.1 of the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (IPCC, 2014), the default CO_2 emission factor for cultivated organic soils (boreal and temperate climate zone) is 7.9 t C/ha/year, with a 95% confidence interval of 6.5–9.4 t C/ha/year. The default emission factor for grassland (land use on drained organic soils) is also high (6.1 t C/ha/year, 95% confidence interval 5.0–7.3 t C/ha/year). Although forestry land use has lower CO_2 and N_2O emission factors than grassland or cropland, default emission factors for forestry on drained organic soils underestimate N_2O emissions from those soils previously used for agriculture (Ernfors *et al*., 2008). Future policies will require the identification of strategies to reduce GHG emissions and enhance sinks. Given the extent of peatland disturbance in Ireland, restoration and rewetting of these ecosystems has considerable potential to contribute to the reduction of land-based GHG emissions. This was given considerable policy impetus by the UNFCCC when it agreed at its December 2011 meeting in Cancún on a new activity, "rewetting and drainage", under the Kyoto Protocol (Document FCCC/KP/AWG/2010/CRP.4/Rev.4). In support of this, the IPCC has published the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (IPCC, 2014), which provides new guidance on estimating and reporting GHG emissions from organic soils and from wetlands, in so far as they are (directly) impacted by human activities ("managed"). Ireland will therefore need to make a decision about which land use activities on peatland it may report under this new "rewetting and drainage" activity.

A vital prerequisite to GHG emissions reduction policy decisions and reporting will be a clear understanding of the nature and extent of agricultural activity on organic soils and this research contributes to the closure of this information gap.

1.1 Objectives

- To conduct an assessment of agricultural activity on drained organic soils in Ireland, specifically the detection of tillage activity, including an uncertainty assessment.
- To estimate annual CO_2 and N_2O emissions from cultivated organic soils.

2 Methods

2.1 Assessment and Uncertainty

Several geographic data sets were available to delineate both agricultural activity and organic soils. These data were reviewed and the most suitable were chosen to identify and map organic soils and tillage activity using a spatial overlay analysis. Uncertainty information is not available for the data sets used in the overlay. An accuracy assessment of the overlay results (the overlay map) was conducted in order to (1) refine the assessment of tillage activity on organic soils and (2) estimate the uncertainty of that assessment. A probability sampling strategy was the most appropriate and statistically rigorous approach for the accuracy assessment (Stehman, 2000). This was achieved by selecting locations on the overlay map and comparing the classification on the map (such as organic soil or mineral soil) with the soil found at the same location (ground truth sites) on the ground. As this method was chosen, a model-based accuracy assessment (such as a Monte Carlo analysis) was not needed (Stehman, 2000).

2.1.1 Existing geographic data

The land parcel identification system (LPIS) data created by the Department of Agriculture, Food and the Marine (DAFM, 2012) were considered a reliable data set for delineating agricultural activity and, specifically, arable crops and were sought through the Environmental Protection Agency (EPA) Inventory Unit (Phillip O'Brien, EPA, personal communication). National data regarding the location of organic soils (peat) are less robust and lack adequate information regarding uncertainty. The focus of the accuracy assessment, therefore, was on the soil type – organic (peat) or mineral – within fields under cultivation for arable crops. The LPIS data were used to locate arable fields and to limit or target samples to areas within the arable fields (DAFM, 2012). All analyses involving the LPIS data were carried out by researchers at the EPA to comply with data confidentiality agreements relating to LPIS data. Further limits were applied to the areas targeted for sampling and these are discussed in the subsection on sampling design (see section 2.1.2). The Habitat Map from the EPA Soil and Subsoil Mapping Project (Fealy *et al.*, 2009) was chosen to identify organic soil locations. The Habitat Map delineates the locations of particular habitat types, using expert rules and the known associations of certain habitats with subsoils, land cover, elevation, elevation-related features and features from Hammond's *The Peatlands of Ireland* (1981) map (Fealy *et al.*, 2009). The classification method was particularly useful for this analysis as it had already applied ancillary environmental data and expert rule-based classification, with a specific focus on mapping peatlands.

2.1.2 Accuracy assessment

A national estimate of uncertainty was needed for organic soils under cultivation for arable crops. It was therefore preferable to include the national extent of these areas in the target area, i.e. the area from which a sample would be drawn. Areas outside the primary areas of interest (peat classes) were also included in the target area. This is because samples drawn from peat classes alone would result in an accuracy assessment that counted only the errors of omission, and accuracy outside the peat classes (errors of omission) would still be unknown. Practical considerations limited the sampling of arable fields outside the peatland boundaries, as sampling outside the peatlands would reduce sampling inside the peatlands and the area of greatest interest. A buffer zone (outside the peatlands) was added to the target area. The buffer needed to be big enough to add more than the edge of a habitat, in order to avoid the introduction of an additional source of error (Powell *et al.*, 2004). As a compromise, the target area was limited to arable fields within at least one of the following: (1) Habitat Map peat classes, or (2) a 100-m buffer around (1), or (3) the areas classified as peatlands by the Derived Irish Peat Map II (DIPM II) (Connolly and Holden, 2009). It was reasoned that sampling within this target area would include a probability greater than 0 of sampling potential errors of omission without unnecessarily concentrating sampling sites that were less likely to have organic soil. For the accuracy assessment, the Habitat Map was reclassified by combining all of the peat classes into one class called "peat" and combining the remaining classes into one class called "other".

Points (rather than areas or polygons) were chosen as the sampling unit and a simple random sample strategy within the target areas was chosen over a stratified random sampling strategy. Random sampling was preferred as it allowed all arable fields within the target area to have an equal probability of being selected and sampled. A stratified random sampling strategy would have allowed control over the number of random points within the peat class in the Habitat Map; however, the accuracy assessment would then have been tied to the peat class boundaries delineated in the Habitat Map (Stehman and Czaplewski, 1998). Simple random sampling simplified analysis of the results and allowed optimum flexibility for stratification after sampling. A random sampling strategy included more sample sites that were less likely to have organic soil, but also allowed the reference data to be used again for assessing additional data sets. For example, the results from the random sample of the target areas may be used to assess the accuracy (regarding organic and mineral soil) of the same (target) areas in the Irish National Soils Map (Creamer *et al.*, 2014).

Random points ($n = 100$) within the target areas were generated using QGIS software. These points were visited (where accessible) and surface samples were collected at 69 locations. A surface sample consisted of a composite of a sample from the point co-ordinate and samples at 5 m and 10 m from the point in each of the four cardinal directions.

Organic soils in Ireland are defined by an organic (peat) layer of at least 30 cm. Peat is defined by 30% organic matter content. Organic soil is usually dark in colour and light in texture compared with mineral soil. Visual assessment was used to classify soil as organic or mineral *in situ.* This was later confirmed using the results of the laboratory analysis of the soil samples.

2.1.3 Analysis and estimates

For the purpose of this assessment, the map classes were aggregated into two classes: "peat" (organic soil) and "other" (mineral soil). The data collected at the sample locations for this accuracy assessment will be referred to as "reference data" and are classified as "organic" (soil) or "mineral" (soil). An error matrix was constructed to compare the map classification with the presence of organic soil or mineral soil at the sites (see Table 3.1). The map classes are entered in the rows of the error matrix and the reference data are entered in the columns. The data in the error matrix in Table 3.1, the size of the target areas (see Table 3.2) and equations 2.1–2.5 (Olofsson *et al.*, 2013) were used to calculate the error matrix based on error-adjusted proportion (see Table 3.3), the producer's accuracy, user's accuracy and overall accuracy, area estimations and confidence intervals (see Table 3.4). Equations 2.1–2.5, summarised below, are described in greater detail by Stehman (2013) and Olofsson *et al.* (2013).

This method and data reporting practice support the integration of these (organic soils under cultivation) estimates into land use change models and associated model-based accuracy assessments (Olofsson *et al.*, 2013).

To amend the systematic classification error in the map classes, the cells (*Pij*) in a matrix of error-adjusted proportions (see Table 3.3) were calculated using the following equation:

$$Pij = Wi\frac{n_{ij}}{n_i} \quad (2.1)$$

where i = a map category (a row in the error matrix; see Table 3.1) and j = a reference category (a column in the error matrix; see Table 3.1) and $Wi = A_{m,i} \div A_{tot}$, where $A_{m,i}$ = the mapped area of category i and A_{tot} = the total mapped area (target area).

The total unbiased area of category j was calculated as follows:

$$A_j = A_{tot} \times P\cdot_j \quad (2.2)$$

where $P\cdot_j$ = the column total of area proportion of category j (see Table 3.3).

The estimated standard errors of the estimated proportion (equation 3.3) and the error-adjusted estimate of the area (equation 3.4) are as follows:

$$S\left(P\cdot_j\right) = \sqrt{\sum_{i-1}^{q} W_i^2 \frac{\frac{n_{ij}}{n_i}\left(1-\frac{n_{ij}}{n_i}\right)}{n_i - 1}} \quad (2.3)$$

$$S\left(A_j\right) = A_{tot} \times S\left(P\cdot_j\right) \quad (2.4)$$

The estimated 95% confidence interval for the estimate of the area for category j is:

$$A_j \pm 2 \times S\left(A_j\right) \qquad (2.5)$$

An estimate of CO_2 emissions was calculated using new area estimates for organic soils under cultivation for arable crops (see Table 3.4) and default emission factors from the *Wetlands Supplement* (IPCC, 2014).

2.2 Carbon-to-nitrogen Ratio Analysis

Soil samples were taken from each site at a depth of 0–15 cm, air dried and put through a 2-mm sieve. These samples were analysed for C and nitrogen (N) content using a CN analyser. The method deployed by Klemedtsson *et al*. (2005) and Ernfors *et al.* (2008) was used to estimate annual N_2O emissions from drained organic soils using the C:N ratio. This was applied to the relationship described by Klemedtsson *et al*. (2005) using the formula:

$$\text{Mean annual } N_2O \text{ emissions} = ae^{\left(-bC{:}N\ ratio\right)} \qquad (2.6)$$

where $a = 481$, $b = 0.37$ and the C:N ratio = 15.9 (mean of all samples).

3 Results

The results of the accuracy assessment and the C:N analysis are presented in the following sections.

3.1 Accuracy Assessment

Organic soil was found at eight of the sample locations. Of these locations, seven were correctly classified as peat on the Habitat Map. Organic soil was found at one sample site classified as "other" on the Habitat Map. Mineral soil was found at 61 of the sample locations. Eighteen of these sites were classified as peat on the Habitat Map. Forty-three of the 61 sample points were accurately classified as "other". These findings are summarised in the error matrix in Table 3.1.

The total area targeted for sampling was 12,600 ha. The proportion of the targeted area classified as peat on the Habitat Map was 29% (Table 3.2).

The estimated proportion of peat in the targeted area (based on the reference data) was 8.2% (Table 3.3). This difference in the two estimates of the targeted area classified as peat is the source of the 28% user's accuracy for peat (72% error of commission). The producer's accuracy for peat is 86.6% (13.4% error of omission); this is the product of one site where peat was found that was classified as "other" on the Habitat Map.

3.2 Carbon-to-nitrogen Ratio Analysis

Klemedtsson *et al.* (2005) report a strong negative relationship between the C:N ratio and N_2O emissions from drained forested histosols. Emissions increased rapidly, the lower the ratio, if the ratio was below 25. The average C:N ratio of the soil at the sample sites where tillage on organic soil was found was 15.9. As

Table 3.1. Error matrix based on sample counts, with rows representing map classes and columns representing reference data classes

Map class	Reference organic	Reference mineral	Total
Peat	7	18	25
Other	1	43	44
Total	8	61	69

Table 3.2. Target area from which the random sample was generated and classification on the Habitat Map

Map class	Area (ha)	Proportion of total target area (%)
Peat	3688	29.3
Other	8912	70.7
Total	12,600	100

Table 3.3. Error matrix based on reference data expressed as the estimated proportion of the target area, with rows representing map classes and columns representing reference data classes

Map class	Reference organic (%)	Reference mineral (%)	Total (%)	User's accuracy (%)	Producer's accuracy (%)	Overall accuracy (%)
Peat	8.20	21.07	29.27	28.00	86.60	77.32
Other	1.61	69.12	70.73	97.73	76.64	
Total	9.80	90.20	1.000			

stated in section 2.2, this C:N ratio was input into the equation presented by Klemedtsson *et al*. (2005) and used to estimate annual N_2O emissions.

Using this approach it was estimated that average N_2O emissions for the sites used in this study were 0.98 g N_2O/m^2/year. This is equivalent to 9.75 kg N_2O/ha/year. When applied to a total area of 1235 ha of peatland under cultivation, the estimate of annual N_2O emissions from this area is 12,043 kg N_2O. It should be noted that other variables such as water table, soil pH and temperature influence N_2O emissions and were not investigated in this study. In addition, the estimate of N_2O emissions is from organic matter decomposition alone. On agricultural sites such as these, there may be additional emissions associated with fertiliser and slurry application that cannot be estimated here. As such, the N_2O emissions were also calculated through the application of a default emission factor of 13, which gives a total emission value of 16,057.41 kg N_2O-N/year (Table 3.4).

For CO_2, the IPCC default emission factor for drained organic soils utilised as cropland in both boreal and temperate climates is 7.9 t C/ha/year (95% confidence interval 6.5–9.4 t C/ha/year). Multiplying our area estimate of 1235 ha by this emission factor (see Table 3.4) gives a value of 9.756 Kt C/year (standard deviation ± 1.79 Kt C/year) emitted as a result of organic soil degradation under arable land use in 2012. Based on uncorrected map data alone, the value is 35.98 Kt C/year (standard deviation ± 1.8 Kt C/ha/year), or 26.22 Kt C/year more than the value based on our corrected area estimate.

Table 3.4. CO_2 and N_2O estimates for organic soils under cultivation for arable crops in 2012 using area estimates, tier 1 default emission factors and the combined uncertainties

Results	CO_2 emission factor (t CO_2-C/year)[a]	Emission estimate (t CO_2-C/year)[b]	N_2O emission factor (kg N_2O-N/year)[a]	Emission estimate (kg N_2O-N/year)	Organic soil under cultivation for arable crops, area estimate (ha)
Estimated value	7.9	9757.97	13	16,057.41	1235.18
95% confidence interval lower[a]	6.5	8028.71	8.2	10,128.52	451.63
95% confidence interval upper[a]	9.4	11,610.74	18	22,233.34	
Uncertainty		18.35%		37.69%	63.44%
Combined uncertainty[c]		66.04%		73.79%	

[a]From the *Wetlands Supplement* (IPCC, 2014).

[b]Results shown are described further in Donlan *et al*. (2016).

[c]Area estimate and emission factor uncertainties were combined following IPCC (2006) guidelines.

4 Discussion

4.1 Accuracy Assessment

Several of the first sites visited raised interesting issues regarding the classification of the observed soil at the sample location and the definition of organic soil. One of our trial sites, for example, was at the edge of a cutover raised bog. The soil at this location was easily identifiable as organic and the peat layer was over a metre deep at the sampled location. On close inspection, mineral soil was also present in pebble-sized chunks within the surface sample (0–30 cm). This is because cultivation leads to mixing of sub-peat or adjacent mineral soil with the organic surface soil. The samples were tested for organic content by the researchers using the loss-on-ignition method; using this method, as the mineral and organic portions mixed, the percentage organic matter in the top 30 cm was 22%. This raised the question of the adequacy of visual inspection, as well as the importance of the definitions of organic soil and peat for this assessment, as organic soils in Ireland are defined by an organic (peat) layer of at least 30 cm and peat is defined by 30% organic matter content. In keeping with the aims of the project, the researchers continued to use the visual inspection method to classify soil as organic or mineral at the sample locations. Surface samples were collected and analysed for C and N content at organic and mineral soil sites. To avoid the misclassification of organic soil (under cultivation) as mineral soil, samples conclusively identified as organic soil *in situ* were not reclassified for accuracy assessment purposes according to C:N analysis results.

Thirty-one of the 100 randomly selected sample sites were inaccessible. The reference data collected for this assessment are more accurate than the map data as some (systematic) error due to misclassification is present in every classified map. These errors are adjusted for using the reference data; however, the reference data were drawn from only a sample of locations and so have the potential for error because of the possibility of the sample not accurately representing the population (Olofssen *et al.*, 2014). Larger sample counts would reduce uncertainty and the confidence intervals associated with the new estimates.

All areas mapped as peatlands by the Habitat Map and under cultivation by LPIS (DAFM, 2012) were included in the target area; therefore, the new estimates (Table 4.1) are national estimates of the total area of organic soil under cultivation for arable crops. Estimates for mineral soils (see Table 4.1) were reported for completeness and transparency only; areas reported are within the target area only.

4.2 Carbon-to-nitrogen Ratio Analysis

In a study based on drained organic forest soils in Sweden, Klemedtsson *et al.* (2005) proposed that the correlation between the C:N ratio and N_2O emissions could provide a basis for scaling up N_2O fluxes from site to national levels. In a more recent study of the same soils, Ernfors *et al*. (2008) found that former agricultural sites were the strongest sources of N_2O and that use of the IPCC default emission factors underestimates regional N_2O emissions. Our estimates of N_2O emissions using Klemedtsson *et al*.'s (2005) findings are lower than estimates made using the tier 1 method and the default emission factors. Default N_2O emission factors for cultivated land use on drained organic soils are higher than those for forested land use on the same soils (IPCC, 2014). This is likely to be the result of emissions associated with fertiliser

Table 4.1. Estimated area of organic soil under cultivation (2012) based on the reference classification and 95% confidence intervals

Soil	Area (ha)	95% confidence interval (ha)
Peat	1235	±784
Mineral	11,365	±784
Total	12,600	

applications on agricultural sites under cultivation for arable crops. For CO_2 emissions, our estimate of 9.757 Kt C/year is small compared with other sources in the agriculture and land use, land use change and forestry (LULUCF) sectors (EPA, 2015). However, it is important to consider not only C efflux attributed to peatland degradation but also the loss of the natural C influx associated with pristine peatlands (Holden and Connolly, 2011). It is well documented that peatland cultivation inevitably leads to loss of the whole peat layer and subsequently high emissions (Regina *et al*., 2015); however, there are few incentives or regulations to effectively minimise these losses. Although the rewetting of peatland in Ireland may not typically focus on arable land use, it is important to consider the long-term sustainability of the cultivation of organic soils and to promote changes in land management practices that are conducive to both economic and environmental longevity (Donlan *et al*., 2016). Planning for such changes requires accurate estimates of the area of peatland under arable use and this study provides a first estimate.

5 Relevance to Policy

This research improves the accounting of drained organic soils under cultivation for arable crops and contributes to national reporting of GHG emissions at higher tiers, with reduced uncertainty, thus providing more reliable information on which to base strategies aimed at reducing GHG emissions in Ireland.

6 Recommendations

The methods and data developed in this research may be used to estimate the area of drained organic soils under cultivation for arable crops and the accuracy of these estimates. Uncertainty associated with these and subsequent estimates could be further reduced by increasing the number of sample sites in the reference data set. The development of national emission factors for organic soils under cultivation for arable crops and for grassland would also further reduce uncertainty and improve GHG emission estimates.

7 Conclusions

The error-adjusted estimate of the area of drained organic soil under cultivation for arable crops is 1235 ha ± 784 ha. This is a considerable improvement on the overlay analysis results (3688 ha). The methods and data developed for this research have contributed to national GHG emission reporting at higher tiers and reduced uncertainty.

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Abbreviations

C	Carbon
CH_4	Methane
CO_2	Carbon dioxide
DAFM	Department of Agriculture, Food and the Marine
DIPM II	Derived Irish Peat Map II
EPA	Environmental Protection Agency
GHG	Greenhouse gas
INSM	Irish National Soils Map
IPCC	Intergovernmental Panel on Climate Change
LPIS	Land parcel identification system
N	Nitrogen
N_2O	Nitrous oxide
UNFCCC	United Nations Framework Convention on Climate Change

Appendix 1 Map of Ireland Showing Location of Study Sites Where Soil Samples Were Collected

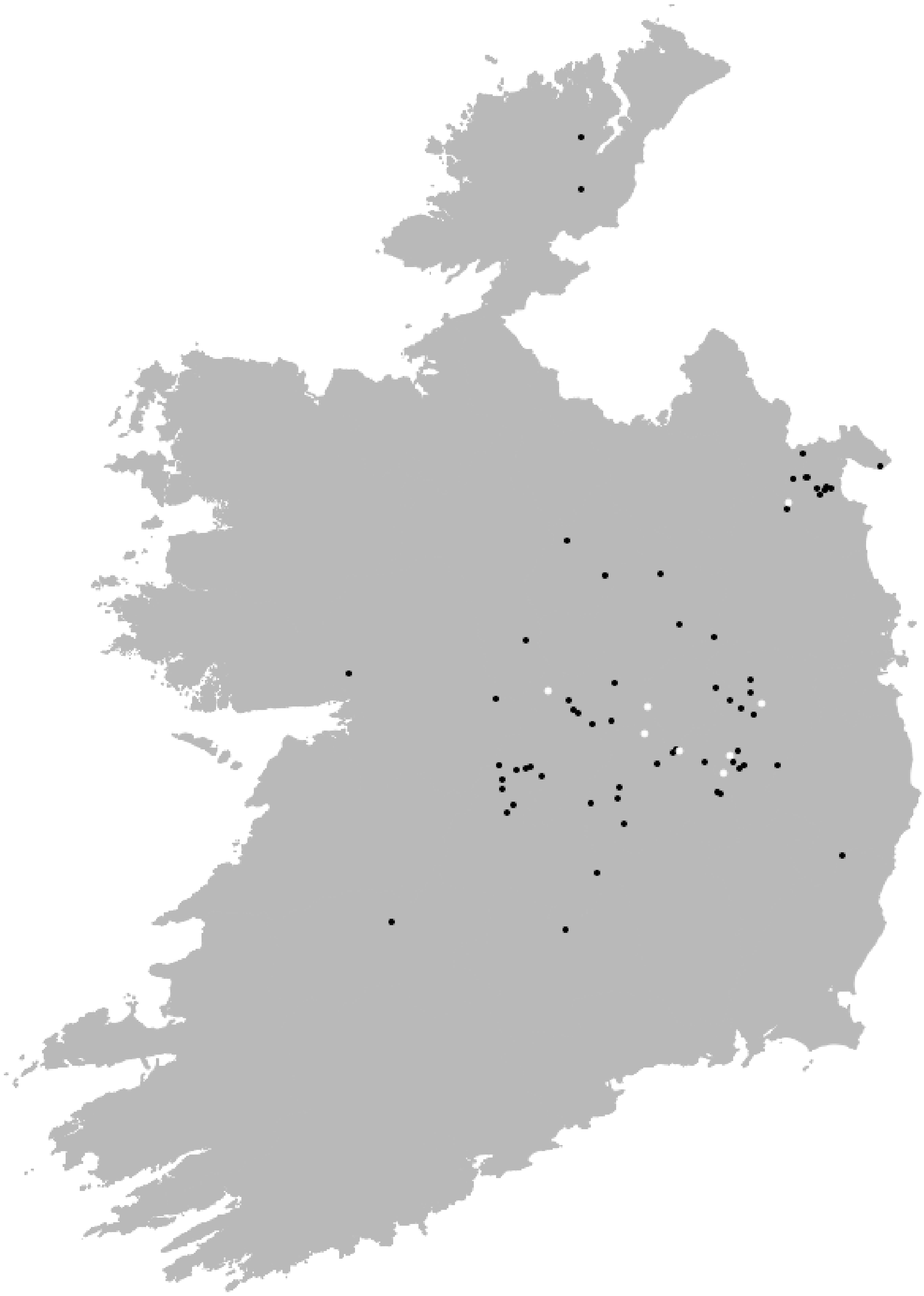

Figure A1.1. Distribution of sample locations and the soil types observed. Black dots are sites with mineral soil and white dots are sites with organic soil.

Appendix 2 Location, Site Classification and Soil Carbon-to-nitrogen Ratio Analysis of Study Sites

Table A2.1. County and province, soil and classification of soil and C:N analysis

Reference classification				Mapped classification[a]			C:N analysis	
Name	County	Province	Soil[b]	HabitatPeat	DIPM_II	INSM_01_02	C (%)	N (%)
0	Limerick	Munster	Mineral	0	0	0	3.19	0.34
2	Tipperary	Munster	Mineral	1	0	1	3.28	0.3
3	Kildare	Leinster	Mineral	0	0	0	6.69	0.54
5	Offaly	Leinster	Organic	1	0	1	7.34	0.54
6	Louth	Leinster	Mineral	1	0	1	4.6	0.41
9	Tipperary	Munster	Mineral	0	0	1	3.25	0.32
11	Offaly	Leinster	Mineral	0	1	0	4.21	0.36
12	Tipperary	Munster	Mineral	0	0	0	2.97	0.33
13	Kildare	Leinster	Organic	1	1	1	3.23	0.36
14	Offaly	Leinster	Organic	1	1	1	28.82	1.77
17	Laois	Leinster	Organic	1	0	1	29.19	1.95
18	Wicklow	Leinster	Mineral	1	0	1	50.69	1.73
24	Louth	Leinster	Mineral	0	0	0	7.81	0.66
25	Laois	Leinster	Mineral	0	0	0	9.83	0.57
26	Meath	Leinster	Organic	0	0	0	5.83	0.45
27	Laois	Leinster	Mineral	0	0	0	2.96	0.3
28	Kildare	Leinster	Mineral	1	1	1	3.98	0.35
31	Louth	Leinster	Mineral	1	0	1	11.71	0.94
33	Laois	Leinster	Mineral	1	0	1	6.67	0.58
34	Laois	Leinster	Mineral	1	0	1	5.72	0.52
35	Laois	Leinster	Mineral	0	1	1	4.3	0.42
36	Louth	Leinster	Mineral	1	0	0	2.62	0.26
37	Longford	Leinster	Mineral	0	1	0	2.79	0.19
38	Donegal	Ulster	Mineral	0	0	1	1.47	0.15
40	Longford	Leinster	Mineral	0	0	0	1.66	0.2
41	Kildare	Leinster	Organic	1	1	1	3.38	0.33
43	Kildare	Leinster	Mineral	0	0	0	1.89	0.17
44	Wexford	Leinster	Mineral	0	1	1	3.3	0.27
45	Louth	Leinster	Mineral	0	0	0	3.45	0.35
46	Kildare	Leinster	Mineral	0	0	0	14.29	0.73
49	Louth	Leinster	Mineral	0	0	0	1.82	0.18
52	Meath	Leinster	Mineral	0	0	1	2.51	0.23
53	Kildare	Leinster	Mineral	1	1	1	3.79	0.39
54	Tipperary	Munster	Mineral	1	0	1	4.25	0.28
55	Laois	Leinster	Mineral	1	0	1	7.07	0.67
57	Kildare	Leinster	Mineral	1	0	1	1.68	0.16
58	Westmeath	Leinster	Mineral	0	0	0	3.15	0.21

Table A2.1. Continued

Reference classification				Mapped classification[a]			C:N analysis	
Name	County	Province	Soil[b]	HabitatPeat	DIPM_II	INSM_01_02	C (%)	N (%)
59	Offaly	Leinster	Mineral	0	0	0	6.95	0.38
60	Galway	Connacht	Mineral	0	1	0	3.45	0.35
61	Louth	Leinster	Mineral	0	0	0	2.14	0.22
62	Offaly	Leinster	Mineral	0	1	0	2.27	0.28
63	Laois	Leinster	Mineral	1	0	1	6.96	0.71
65	Kildare	Leinster	Organic	1	0	1	5.1	0.46
66	Galway	Connacht	Mineral	0	1	0	2.41	0.24
69	Tipperary	Munster	Mineral	1	0	1	4.6	0.23
70	Offaly	Leinster	Mineral	0	1	0	3.45	0.35
71	Laois	Leinster	Mineral	1	1	1	3.49	0.3
73	Kildare	Leinster	Mineral	0	1	1	3.47	0.31
74	Louth	Leinster	Mineral	0	0	0	3.65	0.36
75	Laois	Leinster	Organic	1	0	1	2.27	0.21
79	Offaly	Leinster	Mineral	0	1	0	7.15	0.66
80	Louth	Leinster	Mineral	1	0	1	5.62	0.5
81	Offaly	Leinster	Mineral	1	1	1	2.89	0.3
82	Westmeath	Leinster	Mineral	0	1	0	2.65	0.28
83	Tipperary	Munster	Mineral	0	1	0	3.82	0.32
84	Tipperary	Munster	Mineral	0	0	0	4.06	0.33
86	Tipperary	Munster	Mineral	0	0	0	3.96	0.38
87	Roscommon	Connacht	Mineral	0	1	0	3.67	0.33
88	Kildare	Leinster	Mineral	1	0	1	2.03	0.19
89	Tipperary	Munster	Mineral	0	1	0	9.23	0.87
90	Donegal	Ulster	Mineral	0	1	0	20.58	1.77
91	Meath	Leinster	Mineral	0	0	0	2.87	0.26
92	Louth	Leinster	Mineral	0	0	0	3.27	0.37
94	Offaly	Leinster	Mineral	0	0	0	2.26	0.24
95	Kildare	Leinster	Mineral	0	0	0	1.88	0.2
96	Tipperary	Munster	Mineral	0	0	1	1.44	0.15
97	Laois	Leinster	Mineral	0	0	0	1.45	0.16
98	Laois	Leinster	Mineral	0	0	1	2.8	0.3
99	Offaly	Leinster	Mineral	0	1	0	1.71	0.2

[a]According to the Habitat Map (Fealy *et al.*, 2009), DIPM II (Connolly and Holden, 2009) and Irish National Soils Map (Creamer *et al.*, 2014).

[b]Observed.

Appendix 3 Table of Error Matrix Based on Sample Counts for Peatland Delineation Maps

Table A3.1. Error matrix based on sample counts

Peatland delineation maps	Map data	Reference data			Accuracy (%)		
		Soil organic	Soil mineral	Total points	Producer's	User's	Overall
Habitat Map (Fealy *et al.*, 2009)	Map class						
	Peat	7	18	25	88	28	72
	Other	1	43	44	70	98	
	Total ground truth points	8	61	69			
DIPM II (Connolly and Holden, 2009)	Map class						
	Peat	3	20	23	38	13	64
	Other	5	41	46	67	89	
	Total ground truth points	8	61	69			
Creamer *et al.* (2014)	Map class						
	Peat	7	25	32	88	22	62
	Other	1	36	37	59	97	
	Total ground truth points	8	61	69			
Creamer *et al.* (2014)	Map class						
	Peat	7	23	30	88	23	65
	Other	1	38	39	62	97	
	Total ground truth points	8	61	69			

Rows represent four map datasets and map classes and columns represent reference data classes, showing producer's, user's and overall accuracy (regarding organic/mineral soil within the target areas).

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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Assessment of Agricultural Activity on Drained Organic Soils

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Climate - Water - Sustainability
Identifying pressures • Informing policy • Developing solutions

Authors: Jennifer B. Donlan, Jean O'Dwyer and Kenneth A. Byrne

Peatlands play a vital role in the carbon cycle in terms of carbon storage and biosphere–atmosphere exchange of greenhouse gases. Drainage and conversion to agriculture dramatically alters these processes and transforms the ecosystem from a carbon sink to a carbon source. A key prerequisite for assessing the magnitude of such emissions is to estimate the area of peatland under agricultural use, in this case cultivation.

Identifying Pressures

This project provides the first estimate of the area of peatland under cultivation for agriculture in Ireland. Based on this estimate, the annual emissions of carbon dioxide and nitrous oxide from these soils are estimated.

Informing Policy

Research findings have been published in peer-reviewed journals and presented at national and international conferences. The principal topic addressed was the area of peatlands under cultivation for agriculture in Ireland.

Developing Solutions

By providing an estimate of the area of peatlands under cultivation for agriculture in Ireland, this project addresses an important information gap regarding land use on peatlands. This will enable the contribution of peatlands under cultivation to greenhouse gas emissions in the land use sector to be estimated. This information will inform policy regarding the future land use of peatlands.

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