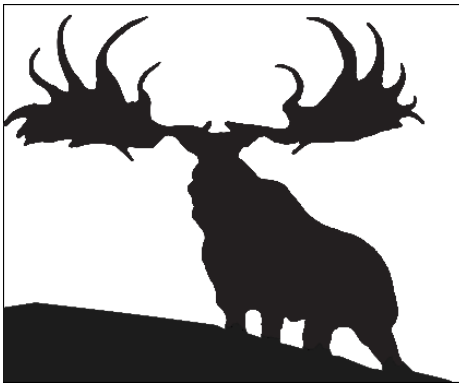

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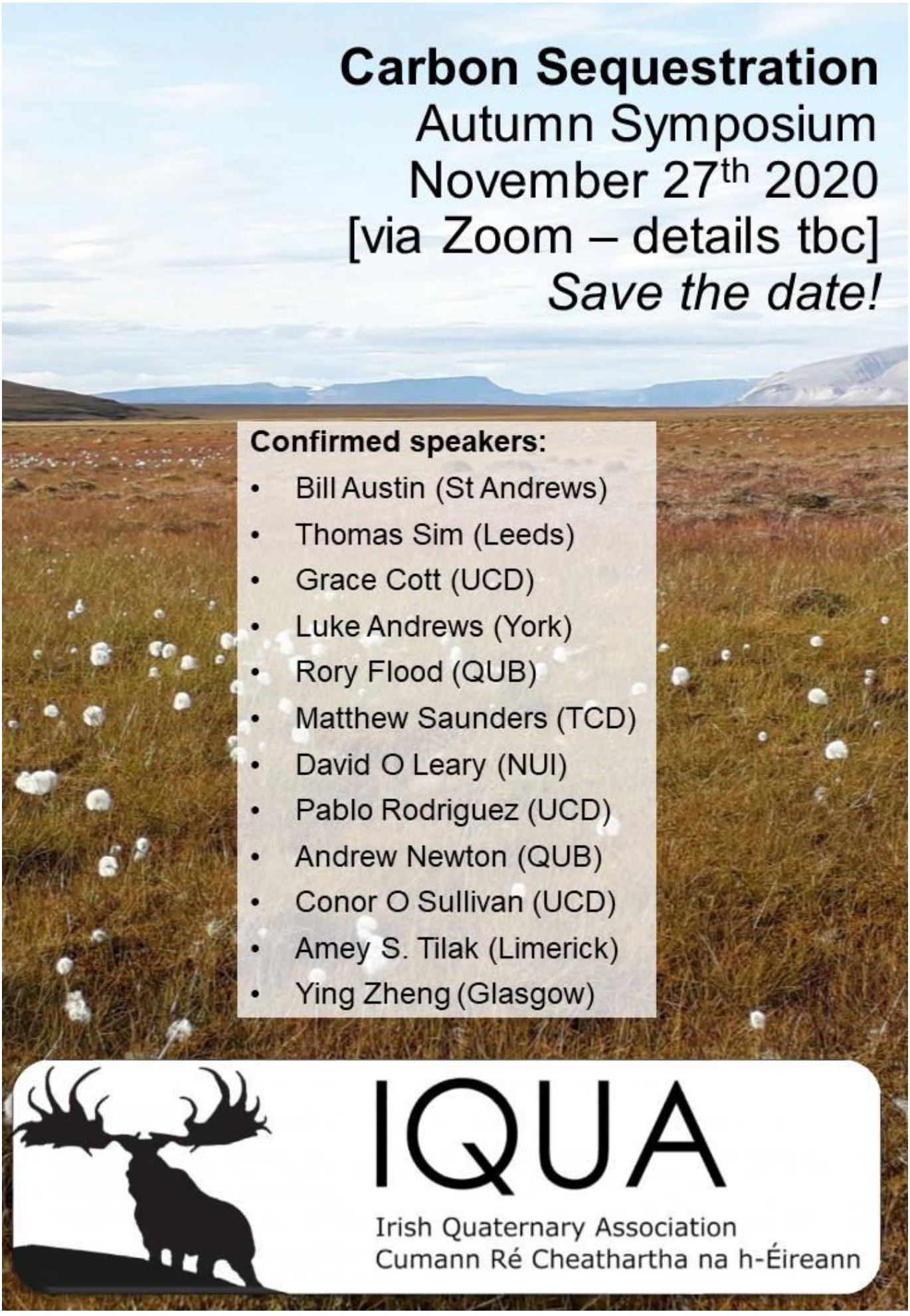
Cumann Ré Cheathartha na h-Éireann

ABSTRACTS

Autumn Symposium 2020

Carbon Sequestration

GT Swindles 28/01/2020


Carbon Sequestration
Autumn Symposium
November 27th 2020
[via Zoom – details tbc]
Save the date!
Confirmed speakers:
• Bill Austin (St Andrews)
• Thomas Sim (Leeds)
• Grace Cott (UCD)
• Luke Andrews (York)
• Rory Flood (QUB)
• Matthew Saunders (TCD)
• David O Leary (NUI)
• Pablo Rodriguez (UCD)
• Andrew Newton (QUB)
• Conor O Sullivan (UCD)
• Amey S. Tilak (Limerick)
• Ying Zheng (Glasgow)
IQUA
Irish Quaternary Association
Cumann Ré Cheathartha na h-Éireann

IQUA Autumn Symposium 2020: Carbon Sequestration

Online: 27th November 2020

Opens at 10 am

10.15-10.20 Welcome from IQUA president (Gill Plunkett)

10.20-10.25 Introduction to the conference (Graeme Swindles)

MORNING SESSION (Chair: Graeme Swindles)

(1) 10.25-10.45 Carbon Storage in Intertidal Environments (C-SIDE): William Austin, University of St Andrews (Keynote speaker)

(2) 10.45-11.00 Put a lid on it: Quaternary sediments and CCS in the North Sea: Andrew Newton,Queen's University Belfast

(3) 11.00-11.15 Divergent responses of permafrost peatlands to recent climate change: Thomas Sim, University of Leeds

(4) 11.15-11.30 Blue Carbon Ireland – Quantifying carbon stocks and sequestration rates in coastal wetlands: Grace Cott, University College Dublin

(5) 11.30-11.45 Land use may influence the composition and biodegradability of dissolved organic carbon in carbon-rich catchment drainage: Ying Zheng, University of Glasgow

(6) 11.45-12.00 Defining peatland zones using self-organising map clustering on airborne radiometric data and OS digital elevation model: David O'Leary, National University of Ireland, Galway (Poster)

12.00-12.30 Virtual lunch break (pets, children, friends and family are welcome!)

AFTERNOON SESSION (Chair: Catherine Dalton)

(7) 12.30-12.45 Estimating allochthonous coastal carbon burial in the western Ganges–Brahmaputra delta over the last 5,000 years: Rory Flood, Queen's University Belfast

(8) 12.45-13.00 Modelling Organic Carbon Accumulation Rates and Residence Times for a Welsh Ombrotrophic Peatland: Luke Andrews, University of York

(9) 13.00-13.15 Assessing the impact of inter-annual climatic variability on rates of net ecosystem carbon dioxide exchange at Clara bog: Matthew Saunders, Trinity College Dublin

(10) 13.15-13.30 Investigation of the CO2 storage potential of the Celtic Sea Basins: Pablo RodriguesSalgado, University College Dublin

(11) 13.30-13.45 Monitoring groundwater depths, pH and redox potential and GHG modelling of a cutover blanket peatland in Galway, Ireland: Amey Tilak, Limerick Institute of Technology

(12) 13.45-14.00 The role of salt in long-term carbon storage offshore Ireland: Conor O'Sullivan, University College Dublin

14.00-14.05 Final comments and conference close from session Chair (Catherine Dalton)

Modelling Organic Carbon Accumulation Rates and Residence Times for a Welsh Ombrotrophic Peatland.

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Northern peatlands store vast quantities of organic carbon (C) which have accumulated over millennia, due to rates of C sequestration exceeding decomposition. The importance of these terrestrial C sinks for climate change mitigation depends upon the Carbon Accumulation Rate (CAR) and the differing residence times of C within the aerobic acrotelm and anaerobic catotelm. Variations in CAR may be compared with proxy-based palaeo-hydroclimatic reconstructions, providing an insight as to how these ecosystems will respond to future climate change.

A number of different methods have been used to quantify CAR in peatlands. Long term Apparent Rates of Carbon Accumulation (LARCA) are based upon the dry bulk density, carbon content and age of the deepest peat at a site. Recent Apparent Rates of Carbon Accumulation (RERCA) are based on a column section between the surface and a given dated horizon (or horizons) within a surface core. These differ from the actual net rate of carbon accumulation however, as these methods do not account for the relatively rapid loss of C in the acrotelm and the slow but persistent loss of C occurring in the catotelm.

Here, three approaches to quantifying C accumulation are used to understand the C dynamics for Cors Fochno, a coastal lowland raised bog in Ceredigion, Wales. LARCA, a Bayesian age-depth model based RERCA and the novel application of a two-pool model of CAR are estimated for the site and compared with palaeo-vegetation and fire history reconstructions. We demonstrate that both age-depth models and LARCA provide reasonable CAR estimates.

Increased macrocharcoal deposition and increases in bulk density associated with fire events artificially inflate CAR. Mean RERCA values for the past c. 1500 years were 19.5% higher than the mean average LARCA estimated from three cores from the site. Using a two-pool model in tandem with an age-depth model yielded reasonable but lower CAR estimates with lower estimate uncertainty (20.4±2.8 g OC m^{-2} yr^{-1}). In addition, the two-pool model provided useful peat C diagnostics, including organic C inputs, decay rates and C transit times. C inputs were estimated to be 138.5±39.8 g OC m^{-2} yr^{-1}. Decay rates within fast cycling C pools were 99.8% faster than slow cycling C pools. Fast-cycling C was estimated to transit the soil system in 23-43 years, compared to 4705-87,032 years for slower cycling C. Rates of C accumulation in fast cycling pools were 82.2% greater than for slow cycling pools (74.3±25.1 g OC m^{-2} yr^{-1} and 13.2±0.9 g OC m^{-2} yr^{-1} respectively).

We conclude that each estimate provides a valuable insight regarding the C dynamics across different timescales. With traditional age-depth based techniques, the relationship between CAR and climate was obscured by the effect of burning or other disturbances, as well as by incomplete decomposition of labile material within the surficial peat. Two-pool model techniques may be used to develop robust CAR estimates with smaller estimation uncertainties than traditional methods. These also quantify and account for differences in CAR, decomposition rates and C transit times between the fast and slow cycling C pools. However other sources of uncertainty within CAR estimations remain, e.g. chronological uncertainty and the effects of fire.

Carbon Storage in Intertidal Environments (C-SIDE)

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C-SIDE project team

GHG emissions and removals resulting from changes in saltmarsh management can be included in national emission accounting under the Land Use, Land Use Change and Forestry (LULUCF) sector. However, they are not included in the UK GHG inventory (GHGI) at this time. The LULUCF sector is currently the only sector of the national GHGI that is a net sink, with scope to offset emissions in other sectors. The IPCC's 2013 Wetland Supplement (IPCC, 2014) to the 2006 IPCC guidelines details expanded guidelines for the quantification and accounting of GHG emissions and removals associated with the management of different wetland types, including drainage and rewetting of tidal marsh (Chapter 4). The UK has elected wetland drainage and rewetting for the second commitment period of the Kyoto Protocol, and using the IPCC Wetland Supplement will report emissions from peatlands in its national inventory by 2022 at the latest under the obligations of the UN Framework Convention on Climate Change (UNFCCC). This also has significance for commitments to the Paris Agreement and the national requirements of the UK's Climate Change Act. Inclusion of saltmarshes in the UK GHGI would provide an important first step necessary to account for, protect, and restore these long-term carbon stores, realising their potential for climate change mitigation. Here, we report on the progress of the NERC-funded C-SIDE project to assess the carbon stocks in UK saltmarsh habitats.

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Blue Carbon Ireland – Quantifying carbon stocks and sequestration rates in coastal wetlands

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Coastal wetlands play a disproportionally large role in the global carbon cycle due to their high primary productivity and unique ability to trap sediments. The carbon stored in vegetated coastal wetlands (including saltmarshes and seagrass beds) has been termed 'blue carbon'. In addition to carbon storage, coastal wetlands provide numerous services such as coastal protection from storm-surge and sea-level rise. There is a striking dearth of knowledge on the dynamics of blue carbon habitats in Ireland and their potentially significant carbon stocks have not been included in Ireland's National Inventory Reports to the UNFCCC. This project aims to quantify carbon stocks and sequestration rates in coastal wetlands and determine factors that lead to carbon preservation. A study of North Bull Island saltmarsh, Co. Dublin has shown the average carbon stock of these wetland soils is 883 ± 400 Mg C ha^{-1} which is over three times the global average per hectare for saltmarsh soils. The carbon density values of North Bull Island saltmarsh are comparable to carbon densities of low-lying blanket bogs. Including above and belowground vegetation, the total carbon stock of this wetland is 107,784 ±785 Mg C. If this wetland were to be degraded through drainage or restriction of tides it would result in the release of 395,567 ± 2,697 Mg CO_2 into the atmosphere. These results highlight the important role that coastal wetlands play in climate mitigation.

Estimating allochthonous coastal carbon burial in the western Ganges–Brahmaputra delta over the last 5,000 years

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The Ganges–Brahmaputra (G–B) fluvial system drains the Himalayas and is one of the largest sources of terrestrial biospheric carbon to the ocean. It represents a major continental reservoir of CO2, as allochthonous carbon is captured from the c. 1–2 billion tons of sediment supplied each year. In this study, the geochemical and grain-size properties of sediments from the western G–B delta are used to investigate variations in, and controls on, allochthonous coastal carbon capture (burial) over the past 5,000 years. Our main findings are: (1) Beta regression of aluminium and silica ratio data is a robust method of estimating allochthonous total organic carbon in sediment from the G–B delta; (2) the estimated rate of sediment deposition over last 5,000 years is between 1.0 and 2.5 mm yr−1, although uncertainty surrounds the reworked origins of these sediments; and (3) temporal variation in the rate of allochthonous total organic carbon accumulation through the last 5,000 years is generated by variability in the prevailing sedimentary depositional processes. The delivery and burial of estimated allochthonous total organic carbon is predicated on the continual supply of sediment to the G–B delta, which future management strategies may need to consider given changing rates of deposition.

Put a lid on it: Quaternary sediments and CCS in the North Sea

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It is unlikely that emission reductions alone will be sufficient for meeting national targets. This will require the removal of CO_2 either directly from the air or when the hydrocarbon source is initially extracted. Carbon capture and storage (CCS) provides a mechanism for this and involves the geological storage of CO_2 in either former hydrocarbon reservoirs or underground aquifers beneath the Earth's surface. The prolific history of oil and gas exploration in the North Sea means that there are many storage sites that could potentially be suitable for upscaling CCS. The Quaternary sediments in the North Sea measure up to 1 km thick and represent a significant part, or indeed all, of the overburden above some potential CO_2 storage sites. Thus, understanding the nature of the Quaternary record in the North Sea is important for identifying potential pathways of fluid migration that might reduce the efficacy of CCS reservoir targets. The work presented here uses a multi-proxy dataset from the North Sea that investigates the Quaternary geological record in order to: 1) unravel what insights this record provides for long-term climate reconstruction in northwest Europe; and 2) the potential implications of this climate record for the efficacy of CCS in areas of the North Sea where the overburden seal is largely comprised of Quaternary sediments.

Defining peatland zones using self-organising map clustering on airborne radiometric data and OS digital elevation model

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Peatlands are becoming recognized as important carbon sequestration centres. Through restoration projects of industrial drained peatlands in which the water table is raised, they may become carbon neutral or possibly carbon negative. Restoration projects require a knowledge of intra-peat variation across potentially large spatial areas. The integration of multidimensional geophysical tools, digital elevation models and satellite remote sensing products, combined with modern data analytical techniques, may provide a rapid means of accessing variations in intra-peat variation of either thickness or water content over such scales. In this study, an airborne radiometric survey, being flown nationally over the Republic of Ireland, combined with a digital elevation model, is used to delineate areas within an industrial raised peatland where peat thickness is consistent. Radiometric data are particularly suited to peat studies as they are sensitive to water content and peat thickness and require relatively little expert knowledge to utilise. Peat, as a mostly organic material, acts as a low signal environment where variations in the signal are linked to intra-peat variation of thickness and/or water content. This study uses an unsupervised machine learning, self-organizing map clustering methodology to group the study site into three zones interpreted as 1) the edge of the bog where peat layer is thinning or there is influence on the radiometric signal from non-peat soils outside of the bog, 2) the normal peat conditions where thickness and saturation appear as a relative constant in the radiometric response, and 3) areas where the peat is either thinner or drier. A ground geophysical survey was conducted to verify this interpretation. The delineation of such spatial variations in the radiometric response could aid any restoration project in the initial stages or act as a baseline study to monitor changes to the peatland during and after a restoration project is complete.

The role of salt in long-term carbon storage offshore Ireland

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Carbon dioxide (CO_2) is one of the most abundant greenhouse gases emitted by human activity, making the capture and storage of CO_2 essential in mitigating global climate change. Removing CO_2 from the atmosphere and storing it for geological periods (10,000+ years) can have a meaningful and positive impact on reducing the effects of climate change and offsetting the CO_2 emitted during the societal transition from hydrocarbons to renewable energy. Therefore, identifying sites with geological characteristics suitable for the long-term storage of CO_2 becomes increasingly important, in particular the identification and mapping of regional seals which will impede the vertical migration of injected CO_2 back to the shallow subsurface and atmosphere. The physical properties of salt (NaCl) make it an ideal seal; salt is a crystalline solid with very low permeability and porosity and behaves like a fluid over geological timescales, making it less susceptible to fracture and leakage relative to other seals such as mudstones. The deformation of salt layers during the evolution of sedimentary basins can also play a role in the formation of structures suitable for CO_2 storage. This study uses a variety of legacy and modern datasets collected for hydrocarbon exploration, primarily borehole and seismic reflection data, to map the distribution and composition of salt within the Slyne Basin, offshore north-western Ireland. Two salt-prone layers are identified, the Late Permian-aged Zechstein Group and the Late Triassic-aged Uilleann Halite Member. These salt layers are already proven to be effective regional seals, with the Uilleann Halite Member acting as a seal for the Corrib gas field and the Corrib North gas discovery. Understanding the distribution of salt within the Slyne Basin will aid in the identification of suitable sites for the long-term storage of CO_2 and provides paleogeographic context for Permian and Triassic salt in other basins offshore Ireland.

Investigation of the CO2 storage potential of the Celtic Sea Basins

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Carbon Capture and Storage (CCS) is considered a key technology to mitigate climate change during the current energy transition. CCS technology can capture CO2 emissions derived from large point sources and sequester it underground in porous geological formations. Ireland has vast offshore basins with great potential for CO2 storage which could therefore contribute to the energy transition and the achievement of EU carbon reduction targets. This study aims to identify potential sites for CO2 storage in the Cretaceous succession of the North Celtic Sea Basin by taking advantage of Ireland's legacy hydrocarbon exploration database. The main research questions are: What are the characteristic properties of reservoir rocks and seals and their spatial distribution? How do the different families of faults affect the seal rock integrity? Which faults are most susceptible to reactivation during CO2 injection? Where are the most promising sites for CO2 injection and storage? What volumes of CO2 can potentially be stored at these sites? To answer these questions, multiple observations from individual boreholes including pressure tests, oil and gas show distribution, core and fluid sample analyses and stress indicators are combined with the existing regional-scale mapping of faults and key horizons to reduce the main uncertainties relating to i) the nature and spatial distributions of reservoir and seal rock formations, ii) the distribution and characteristics of faults and iii) estimates of potential CO2 storage volumes This project represents a detailed study of the geological storage potential in the North Celtic Sea Basin and it is expected to become a reference for future storage project development.

Assessing the impact of inter-annual climatic variability on rates of net ecosystem carbon dioxide exchange at Clara bog.

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Peatland ecosystems are integral to the mitigation of climate change as they represent significant terrestrial carbon sinks. In Ireland, peatlands cover ~20% of the land area but hold up to 75% of the soil organic carbon stock however many of these ecosystems (~85% of the total area) have been degraded due to anthropogenic activities such as agriculture, forestry and extraction. Furthermore, the carbon stocks that remain in these systems are vulnerable to inter-annual variation in climate, such as changes in precipitation and temperature, which can alter the hydrological status of these systems leading to changes in key biogeochemical processes and carbon and greenhouse gas exchange. During 2018 exceptional drought and heatwave conditions were reported across Northwestern Europe, where reductions in precipitation coupled with elevated temperatures were observed. These conditions were also observed in Ireland where, for example, precipitation received at the Clara bog research platform in 2018 was reduced by 213 mm relative to the preceding 10-year average and was 301 mm lower than precipitation received in 2019. These differences in precipitation altered the hydrological dynamics of this ecosystem resulting in changes in water table height and rates of carbon dioxide uptake and release. In this paper we investigate the impacts of these environmental conditions on gross primary productivity and ecosystem respiration and report on the vulnerability and resilience of these ecosystems to act as a net carbon sink during periods of exceptional inter-annual climatic variability.

Divergent responses of permafrost peatlands to recent climate change

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Abstract

Permafrost peatlands are found in high-latitude regions and store globally-important amounts of soil organic carbon. These regions are warming at over twice the global average rate, causing permafrost thaw and exposing previously inert carbon to decomposition and emission to the atmosphere as greenhouse gases. However, it is unclear how peatland hydrological behaviour, vegetation structure and carbon balance, and the linkages between them, will respond to permafrost thaw in a warming climate. Here we show that permafrost peatlands follow divergent ecohydrological trajectories in response to recent climate change within the same rapidly warming region (northern Sweden). Whether a site becomes wetter or drier depends on local factors and the autogenic response of individual peatlands. We find that bryophyte-dominated vegetation demonstrates resistance, and in some cases resilience, to climatic and hydrological shifts. Drying at four sites is clearly associated with reduced carbon sequestration, while no clear relationship at wetting sites is observed. We highlight the complex dynamics of permafrost peatlands and warn against an overly-simple approach when considering their ecohydrological trajectories and role as C sinks under a warming climate.

Monitoring Groundwater Depths, pH and Redox Potential and GHG Modelling of a Cutover Blanket Peatland in Galway, Ireland

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The Irish partners in Limerick Institute of Technology (LIT) working with EU INTERREG Carbon Connects Peatland Project for reducing high carbon footprint of drained peatlands in North-West Europe using sustainable bio-based business models for farmers on their rewetted peatlands. The LIT in collaboration with private landowner and Freshwater Pearl Mussel (PMP) are monitoring the carbon sequestration potential of 9 ha cutover blanket peatland in Galway, Ireland. The monitoring conducted in two phases: pre-rewetting (May-October 2020) and post-rewetting (November 2020-December 2021). The groundwater levels, pH and redox potential monitored daily at different spatial locations using data loggers and vegetation survey conducted. The carbon in peat and water also measured in pre-rewetting period. The groundwater levels, vegetation types along with land management factors utilized for modelling GHGs using “Site Emissions Tool” developed by VHL, Netherlands. The pre-rewetting monitoring results showed that groundwater levels, pH and redox potential varied from 2.5 cm to 23 cm, 3.86 to 6 and -131 mV to +403 mV respectively. The SET results showed that the “Global Warming Potential (GMP) of the cut-over blanket peatland was +5.11 tCO_2 equivalent per hectare per year”. The SET tool will quantify carbon gain or losses using pre and post-rewetting data i.e. groundwater levels, vegetation types and land management factors.

Land use may influence the composition and biodegradability of dissolved organic carbon in carbon-rich catchment drainage

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The terrestrial flux of dissolved organic carbon (DOC) is the largest transfer of reduced C from land to aquatic systems. Land use is suggested to influence the concentration and composition of fluvial DOC. However, little is known about whether this propagates through to affect in-stream DOC reprocessing.

In this study, we examined water from a 5.7 km^2 peaty headwater catchment in Scotland to explore how aquatic DOC composition is affected by wind farm-related land uses, and how DOC biodegradation may be influenced by its composition. The one-year monthly water monitoring showed that DOC in the felled sub-catchment had greater concentration, but was less humified (smaller $SUVA_{410}$, larger E_2/E_4) than the other one dominated by wind turbines. This may be due to younger DOC from the breakdown of residual branches in felled catchment, or more humification in soils in the wind farm areas.

We further incubated the stream water from these sub-catchments in dark to explore DOC biodegradability. Only 2.9-12.1% (0.60-2.74 mg/l C) of DOC was biodegraded over 21 days, less than many other studies. Weekly UV-visible measurements and fluorescence excitation-emission matrices with parallel factor analysis (PARAFAC) revealed that protein-like florescence component C6 changed actively with biodegradable DOC (BDOC) removal. The initial $SUVA_{254}$, $SUVA_{410}$, C6, and concentrations of SRP and TON were good as single predictors for BDOC loss. SUVAs and C6 likely reflected the loss of refractory/labile DOC pools. Spatially, larger BDOC loss was found in the wind turbine-dominated sub-catchment, in late winter and summer, which may be because of greater nutrient concentrations, less DOC aromaticity and more labile DOM material. However, although little DOC was lost (≤12.1%), the C loss was comparable to other research if normalised for the length of incubation, which suggests that intra-site, other factors influence the capacity for DOC degradation.

This research indicates the composition of soil-derived DOC in freshwater can vary over space and time and in response to land use. In turn this inherited composition can affect the cycling of DOC in aquatic continuum, which potentially impacts C loss from freshwater to atmosphere and export to oceans.