Waterborne carbon from organic soils in Ireland

Role in the Net Ecosystem Carbon Balance

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Irish NOM 2016

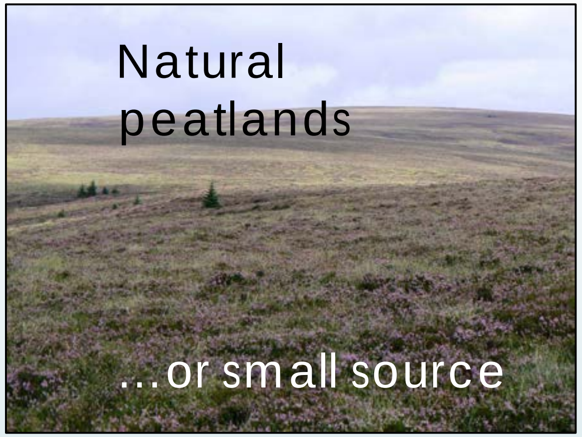
Organic soils/peat soils

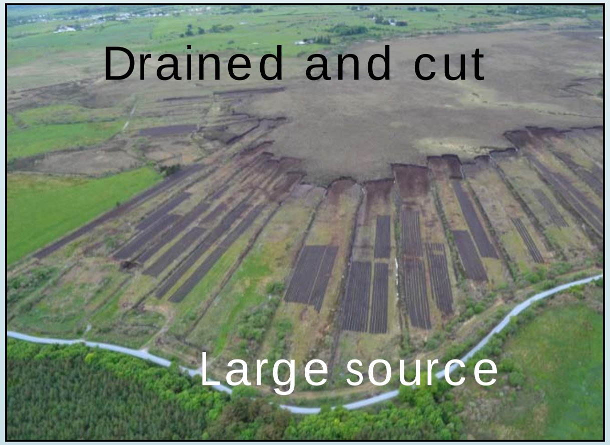
- 1.3 M ha (1/5th territory); extensively modified
- Carbon dense soil (>15% organic C but most peat soils 40-55% C)
- Natural peatlands are sink of CO_2 and source of CH_4 =>accumulate C over millennia
- Drained organic soils are hot spots for CO_2 emissions (Renou-Wilson et al 2014; Wilson et al 2015)
- Aquatic C loss large component of the C budget in peat catchment (Dinsmore et al, 2010)
  - Net Ecosystem Carbon Budget = $\Delta CO_2 + \Delta\ CH_4$ + DOC + POC + DIC + pCO_2
  - Fluvial loss represents 15-50% of total GHG emissions (Evans et al 2016) =>off-site CO_2 emissions
- Significance of DOC acknowledged in the 2013 Wetlands Supplement (IPCC 2014)

Today: waterborne C from Irish organic soils

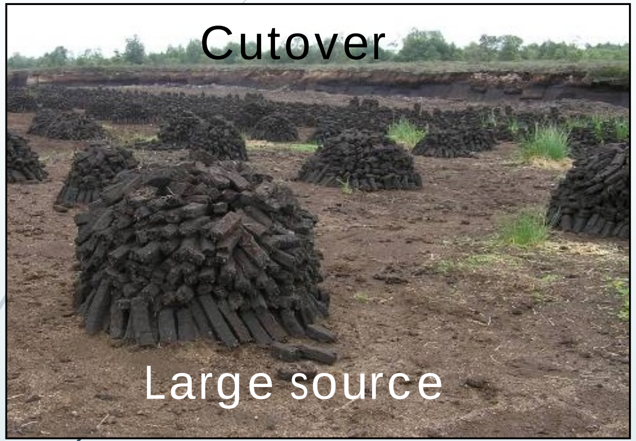
- Natural and managed organic soils: GHG budgets
- Waterborne C fluxes from natural and utilised organic soils in Ireland
- Significance from a climate perspective
  - Net Ecosystem Carbon Balance (gaseous + fluvial)
  - Compare with default emission factors in Wetlands Supplement
  - Fate of waterborne C

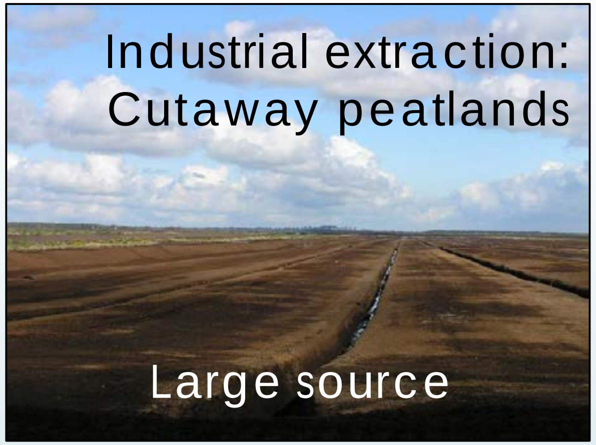
GHG emissions/removals for peatlands LUC

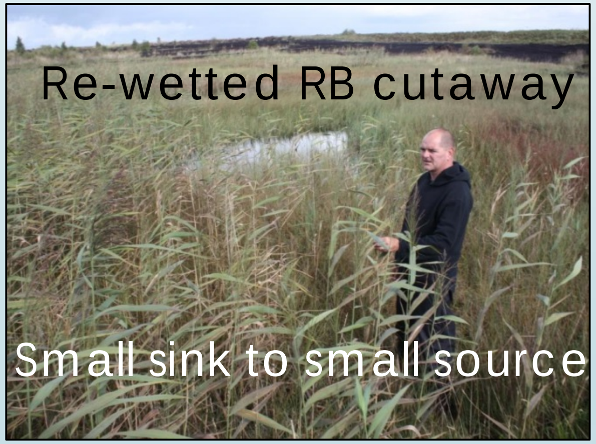


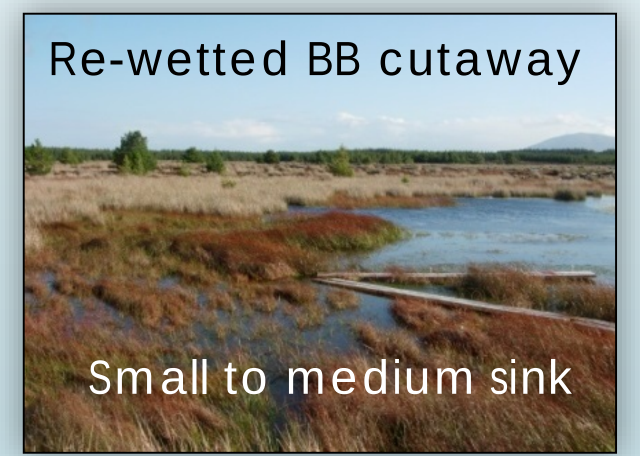


GHG emissions/removals for peatlands LUC



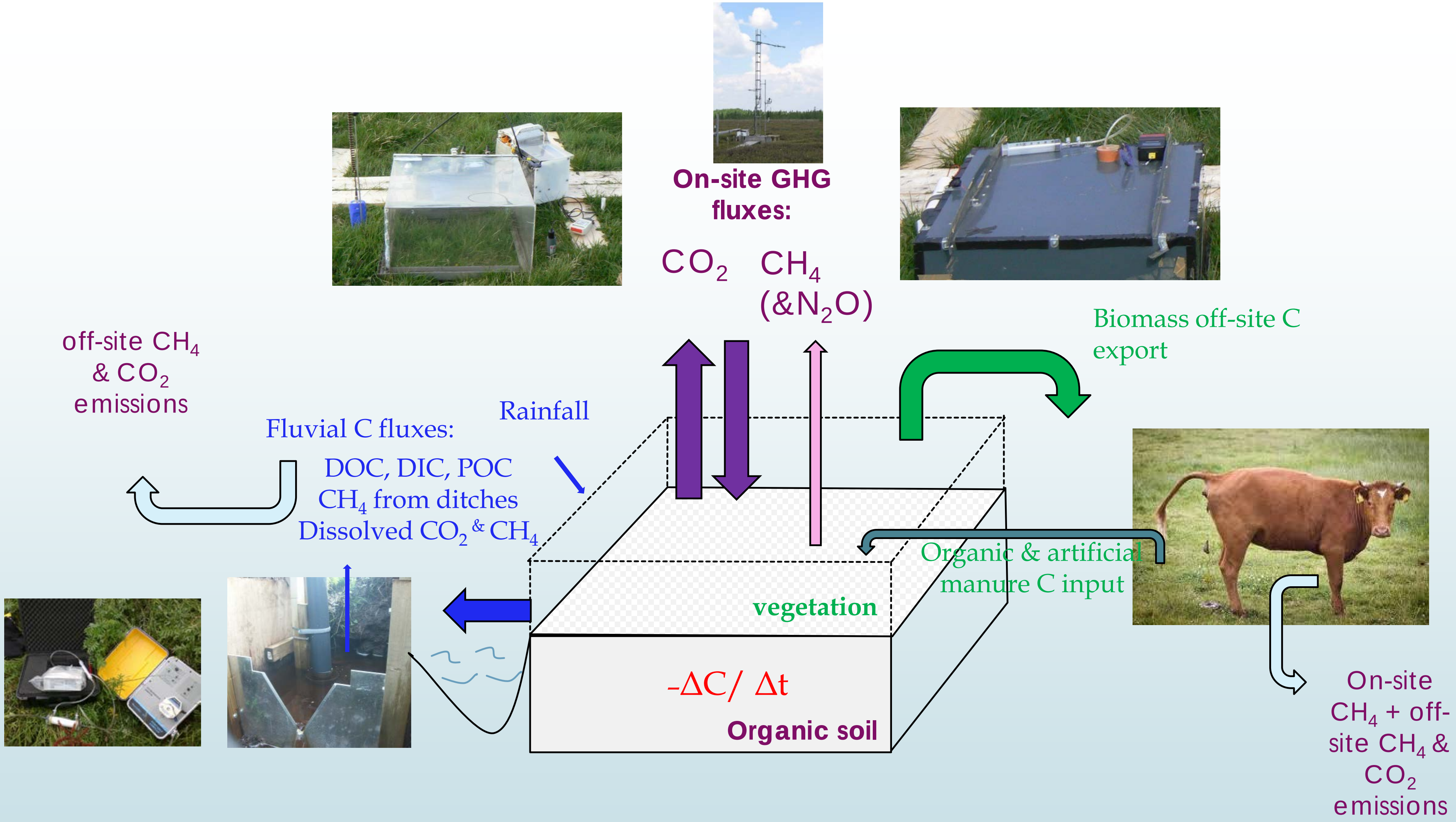






Peatland land use categories, estimated areas (ha) and published/ ongoing C studies in ROI.

Land Use Category	Area (ha)	% total area	GHG studies
Pristine			
Blanket bog	216,599	13.6	Laine et al.(2007), Sottocornola & Kiely (12005, 2010), **Koehler et al.(2011),** McVeigh et al.(2014)
Raised bog	30,874	1.9	Wilson(2008)
Fen	21,277	1.3	--
Agriculture			
Grassland drained	293,765	18.4	**Renou-Wilson et al.(2014), Barry et al.(2015)**
Grassland rewetted	Unknown	Unknown	Renou-Wilson et al. (2016)
Arable	1,235	0.1	--
Forestry			
Drained	293,000	18.4	Byrne et al.(2007), Saunders et al. (In prep)
Rewetted	12,000	0.8	Rigney et al. (PhD) & Renou-Wilson et al (In prep)
Industrial peat extraction			
Production fields	70,000	4.4	Wilson et al.(2015)
Scrub	20,000	1.3	Byrne et al.(2007)
Rewetted	23,000	1.4	Wilson et al.(2007, 2009, 2012, 2013, 2016)
Domestic peat extraction			
Blanket bog	286,516	18.0	Renou-Wilson et al.(2011)
Raised bog	271,692	17.0	Wilson et al.(2015)
Rewetted/restored	Unknown	Unknown	**Regan et al. (NPWS funded),** Renou-Wilson et al (In prep)
Degraded (overgrazing)			
Blanket bog	54,205	3.4	--

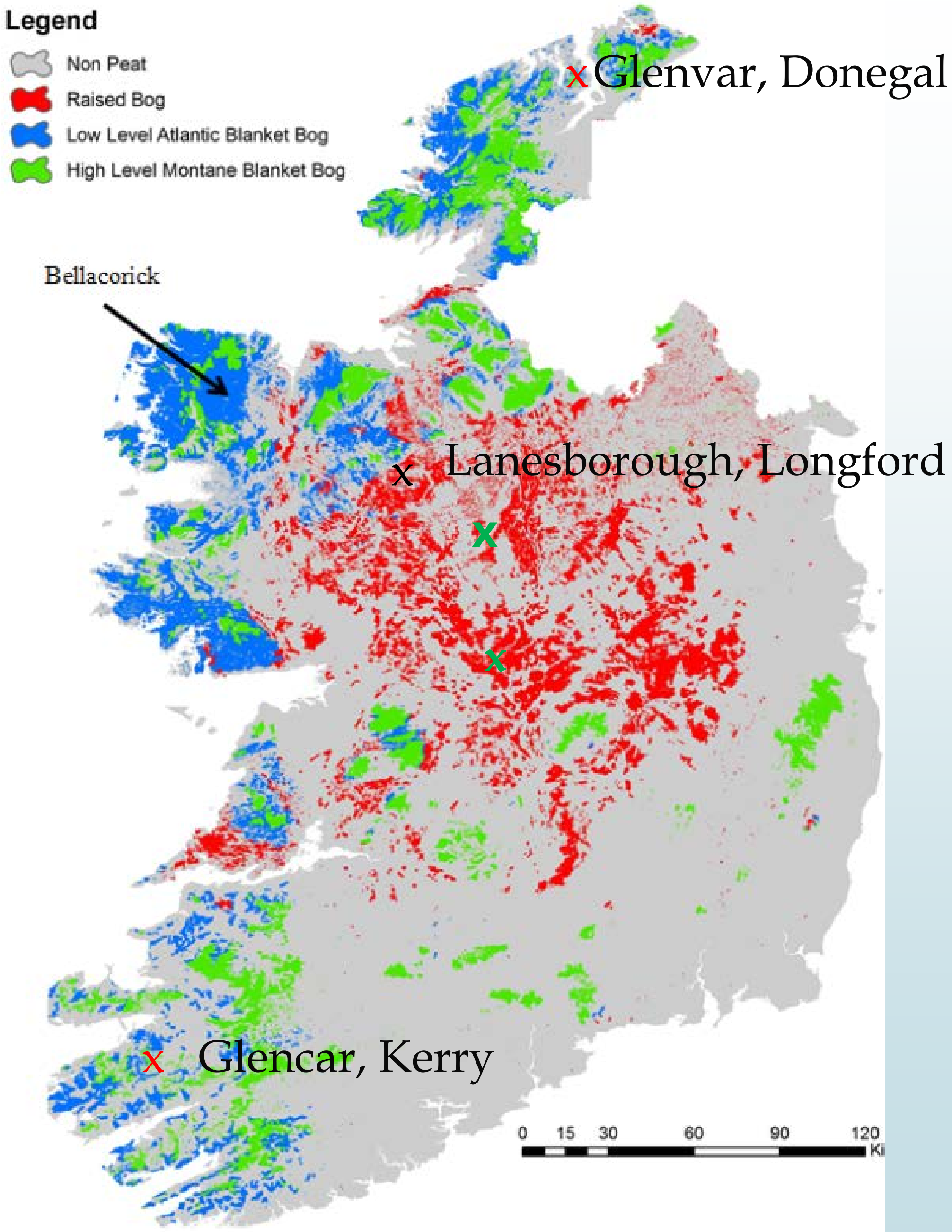


$-\Delta C/\Delta t = \sum$ carbon emissions and removals = $\sum$C inputs and exports = Net Ecosystem Carbon Balance

Renou-Wilson et al. 2015.

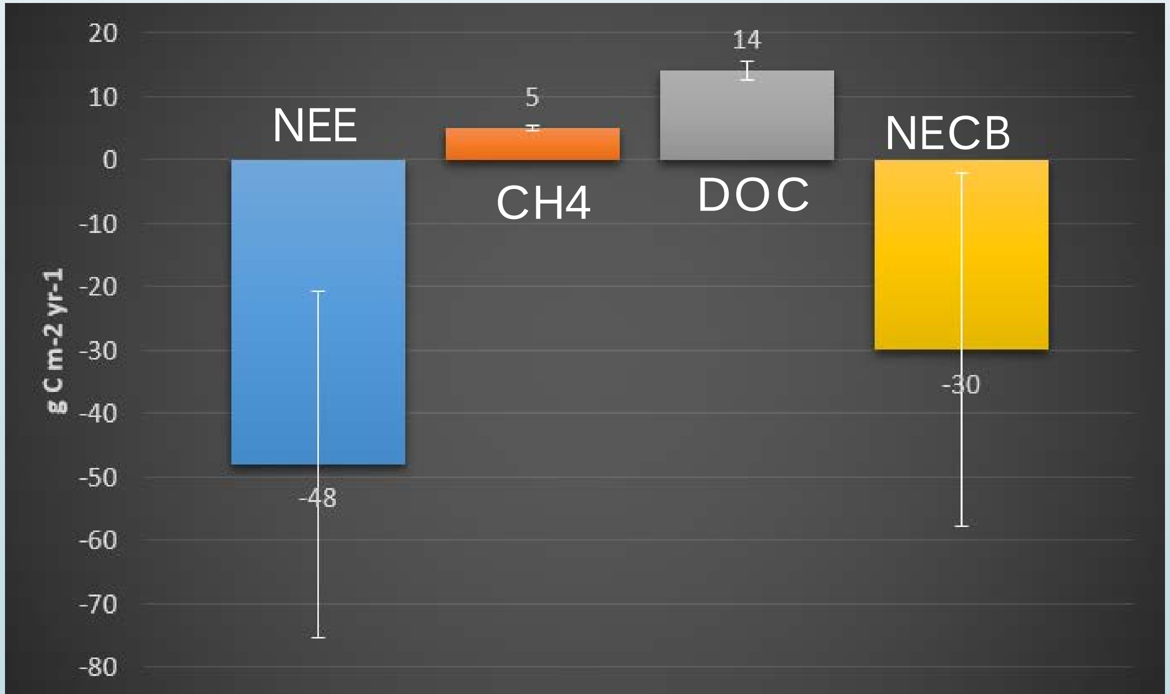
- DOC and POC fluxes quantified at 3 sites with the purpose of integrating it into a Net Ecosystem Carbon Balance.
  - 1 natural peatland (Kerry)
  - 2 managed grasslands:
    - 1 nutrient poor (Donegal)
    - 1 nutrient rich (Longford)

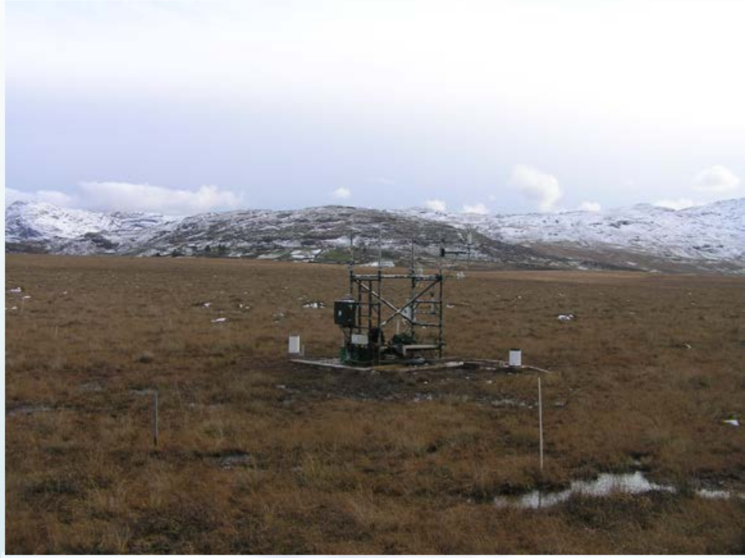
- DIC fluxes (incl. pCO_2) measured at 2 grassland sites



Natural Atlantic blanket bog: Kerry (Koehler et al, 2011)

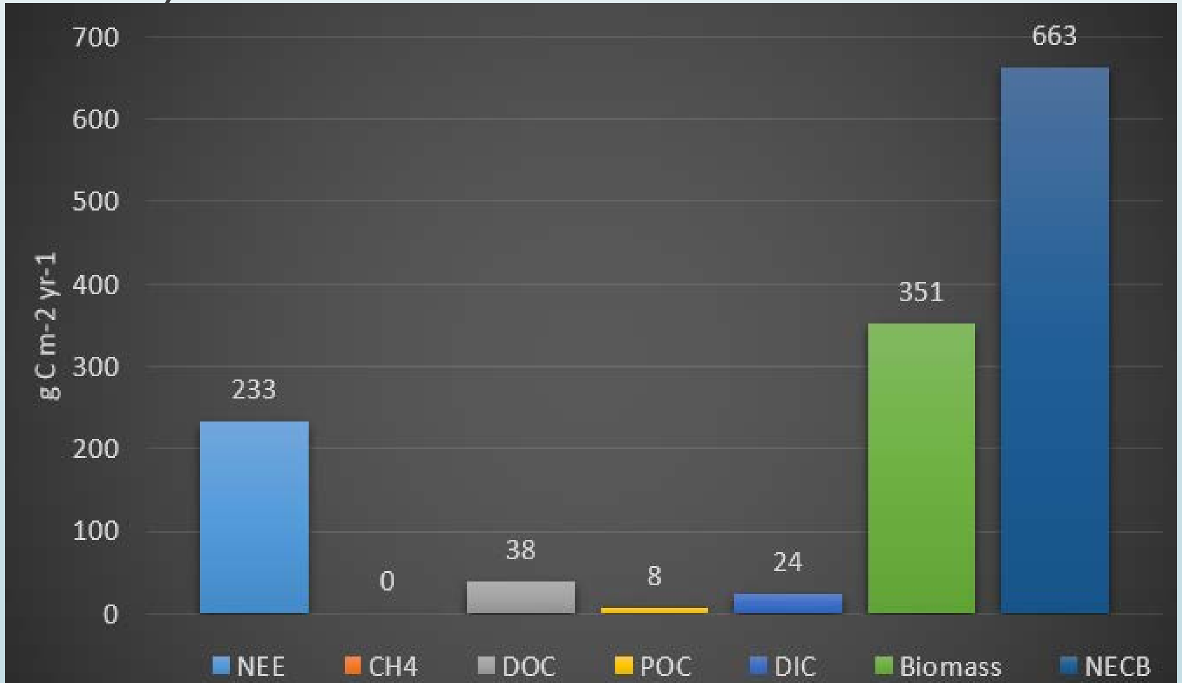
- DOC flux =14 g C m^{-2} yr^{-1} Low range of temperate natural peatlands 21 g C m-2 yr-1 (Evans et al 2016)
- POC flux =1 g C m^{-2} yr^{-1} (= rainfall DOC input)
- Highest DOC flux with high rainfall season
- Does not accumulate DOC as flushed by rain
- DOC = 29% of NEE but 2/6 years DOC+CH4 > NEE





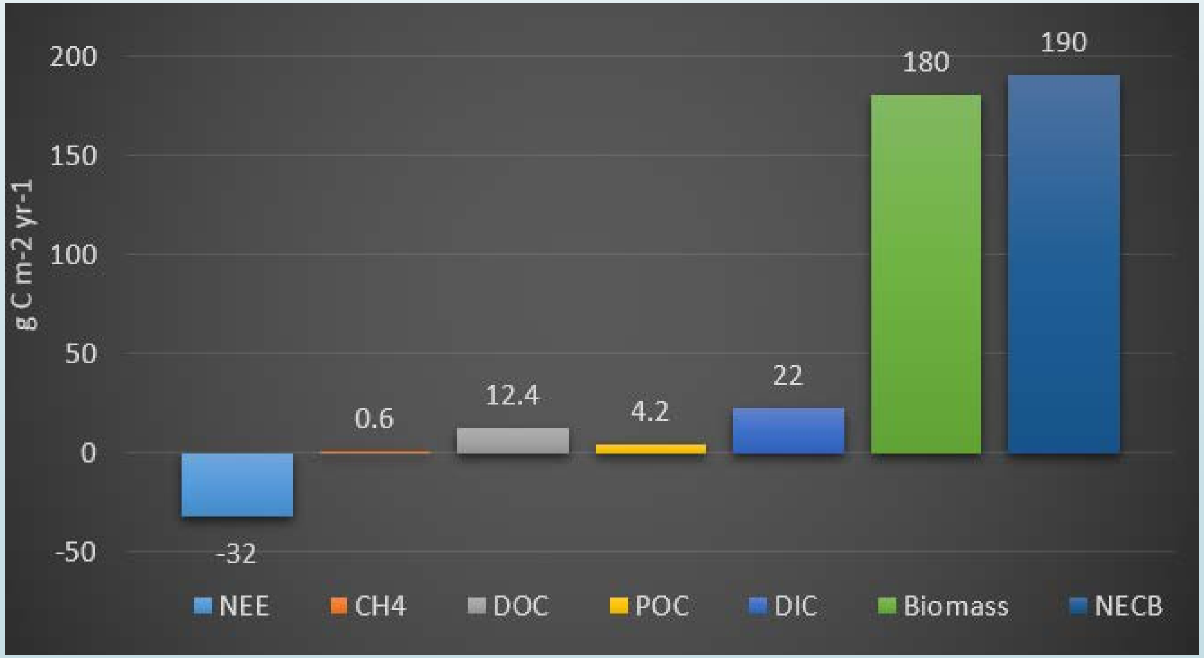
Rich organic soils under grassland: Longford (Renou-Wilson et al, 2014; Barry et al 2016)

- Consistent DOC concentrations; high POC variations
- DOC flux = 37.7 g C m^{-2} yr^{-1}
- POC flux = 8 g C m^{-2} yr^{-1}
- DIC flux = 24 g C m^{-2} yr^{-1}
- Total waterborne C export: 70 g C m^{-2} yr^{-1} (29% of NEE)



Poor organic soils under grassland: Donegal (Renou-Wilson et al, 2014; Barry et al, 2016)

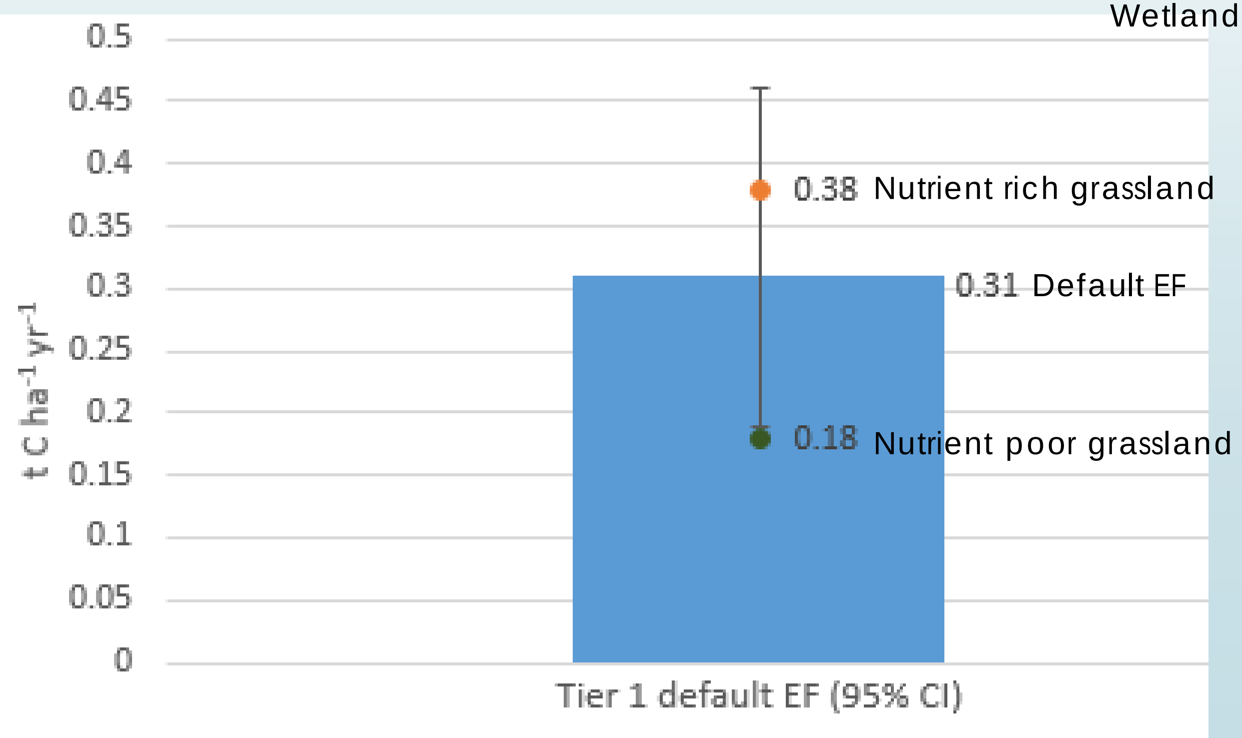
- DOC conc peaks after dry period; Large IAV
- DOC flux = 12.4 g C m^{-2} yr^{-1}
- POC flux = 4.2 C m^{-2} yr^{-1}
- DIC flux = 22 g C m^{-2} yr^{-1}
- Total waterborne C export: 39 g C m^{-2} yr^{-1} (≈100% NEE)



Comparing DOC with IPCC default EF

TABLE 2.2 DEFAULT DOC EMISSION FACTORS FOR DRAINED ORGANIC SOILS				
Climate zone	$DOC_{FLUX\_NATURAL}$ (t C $ha^{-1}yr^{-1}$)	$\Delta DOC_{DRAINAGE}$ [a]	$Frac_{DOC-CO_2}$	$EF_{DOC\_DRAINED}$ (t C $ha^{-1}yr^{-1}$)
Boreal	0.08 (0.06–0.11)	0.60 (0.43–0.78)	0.9 (± 0.1)	0.12 (0.07–0.19)
Temperate	0.21 (0.17–0.26)			0.31 (0.19–0.46)
Tropical	0.57 (0.49–0.64)			0.82 (0.56–1.14)

Wetland Supplement (IPCC, 2014)



Fate of Waterborne C:

contribution to CO_2 emissions or lake/marine sediments?

DOC

- IPCC fraction = 90% re-mineralised back to atmosphere
  - Rapidly photodegraded
  - CO_2 emissions>sedimentary C burial in peaty catchment
  - Small sink in estuaries via flocculation
  - Small sink in marine sediments

- Our studies: Labile DOC using dark incubations
  - potentially 5-10% to be re-mineralised over weeks
  - but missing photodegradation and
  - use by heterotrophic organisms

POC

- Less reactive than DOC
- Likely redeposited in downstream floodplain = reburial

An integrated C observation and analysis system

- Current GHG & fluvial C monitoring not adequate given 20% cover
- Not representative of all LUCs (turbary > 0.5M ha)
- Need to increase scale and duration of measurement from research scale → ICOS
- DOC & POC in specific sites: cutover and cutaway (Lundin et al. 2015)
- Rewetted bogs: reversible effect of drainage on DOC (Evans et al. 2016)
- Climate change vulnerability (increased winter rainfall when DOC exports are highest)

Take-home message

- Organic soils in Ireland: a carbon issue at soil-atm and soil-water interfaces
- Large variability in waterborne C losses from managed organic soils in Ireland with great significance from a climate perspective
  - Nutrient poor wet grassland over organic soils: DOC ≈ NEE (overall small source/neutral)
  - Nutrient rich grassland over organic soils DOC ≈ 30% NEE (overall large source)
- C observations in Irish peatlands not adequate (→Integrated Carbon Observation System)

References

- Barry, C.D., Renou-Wilson, F., Wilson, D., Müller, C., Foy, R.H., 2016. Magnitude, form and bioavailability of fluvial carbon exports from Irish organic soils under pasture. Aquatic Sciences 78, 541-560.
- Evans, C., Renou-Wilson, F., Strack, M., 2016. The role of waterborne carbon in the greenhouse gas balance of drained and re-wetted peatlands. Aquatic Sciences 78, 573-590.
- Dinsmore, K.J., Billet, M.F., Skiba, U.M., Rees, R.M., Drewer, J., Helfter, C., 2010. Role of the aquatic pathway in the carbon and greenhouse gas budgets of a peatland catchment. Global Change Biology 16, 2750-2762.
- IPCC, 2014. 2013 Supplement to the 2006 Inter-Governmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories: Wetlands. IPCC, Switzerland.
- Koehler, A.-K., Sottocornola, M., Kiely, G., 2011. How strong is the current carbon sequestration of an Atlantic blanket bog? Global Change Biology 17, 309-319.
- Renou-Wilson, F., Barry, C., Müller, C., Wilson, D., 2014. The impacts of drainage, nutrient status and management practice on the full carbon balance of grasslands on organic soils in a maritime temperate zone. Biogeosciences 11, 4361-4379.
- Wilson, D., Dixon, S.D., Artz, R.R.E., Smith, T.E.L., Evans, C.D., Owen, H.J.F., Archer, E., Renou-Wilson, F., 2015. Derivation of greenhouse gas emission factors for peatlands managed for extraction in the Republic of Ireland and the United Kingdom. Biogeosciences 12, 5291-5308.