The Potential of Irish Grassland Soils to Sequester Atmospheric Carbon

Expert Statement: Royal Irish Academy Climate Change and Environmental Sciences Committee

March 2016

Expert Statement: Royal Irish Academy Climate Change and Environmental Sciences Committee

The Potential of Irish Grassland Soils to Sequester Atmospheric Carbon

Irish grasslands sequester (fix) significant amounts of atmospheric carbon in their soils, which will only be acknowledged in IPCC greenhouse gas (GHG) accounting methods when Ireland can produce evidence-based Measurement, Reporting and Verification (MRV) of carbon sequestration.

As of 2014, Irish agriculture contributed an estimated 33% of national GHG emissions compared to an EU average of 9%. With the implementation of the Department of Agriculture's Food Harvest 2020, the 2020 projection for Irish agricultural emissions is an increase of 9% (EPA, 2013). These large percentages have resulted in calls within Ireland and Europe for Ireland to reduce its agricultural GHG emissions.

The latest land cover distribution statistics across Europe (EUROSTAT, 2012) estimate that Ireland has the largest proportion of land under grassland (67.1%) and the lowest proportion of land cover under woodland and shrubland (15.2%). This compares to an EU average grassland cover of 19.5% and woodland and shrubland of 45.2%. Sweden has the largest cover of woodland and shrubland at 76.6% and as woodland and forestry are known to sequester large amounts of carbon in their biomass and soils, Sweden benefits significantly in its estimates of atmospheric carbon removals using the established IPCC GHG accounting methodologies.

Here, we make the argument that grassland soils sequester carbon and that this should also be taken into account in GHG accounting methodologies. This statement focuses on soil carbon and does not include other pathways such as dissolved organic carbon (in streams) or methane from soil or animals. Ours is a two-point argument. Firstly we review the international literature that verifies that temperate grasslands sequester atmospheric carbon into the grassland biomass and soil. Secondly, we point to the international literature that shows that many soils under grasslands are currently under-saturated with carbon. Linking these two facts, we explain that grassland soils in Ireland are currently sequestering carbon in the roots and soils below the grassland soil surface.

Firstly, a wealth of international literature has shown that temperate grasslands in Europe are currently sequestering carbon. This has been demonstrated using measurements of carbon dioxide uptake and release to the atmosphere. For example, the carbon budgets of nine grassland sites using varying management practices covering a major climate gradient across Europe were measured by Soussana et al. (2007) and they found that the carbon storage (net annual biome productivity below ground in soils and root systems) ranged from 0.25 to 1.75 t C ha^{-1} yr^{-1}. The sites with most carbon sequestered were on the Western edge of Europe with a temperate moist climate. By coupling carbon flux measurements with farm management data, Byrne et al. (2007) quantified the farm scale carbon balance during 2004 for two dairy farms in South West Ireland and found that both were sequestering close to 2 t C ha^{-1} in the year.

Secondly, there is now a growing body of international published research from Europe, New Zealand, China and the USA (Feng, 2012; Feng et al., 2013) showing that many grassland soils are not carbon saturated, and therefore have the potential to sequester additional carbon from the atmosphere for many years into the future if the land management regime is changed to favour this (Jones and Donnelly, 2004; Allard et al., 2007). The capacity of a soil to sequester organic carbon can in theory be estimated as the difference between the existing soil organic carbon (SOC) and the SOC saturation value. This term is reported in the literature as either the SOC sequestration potential (SOCp) or the SOC deficit. The C saturation concept assumes that each soil has a maximum SOC storage capacity which is primarily determined by the characteristics of the fine mineral fraction (Beare et al., 2014). Angers et al. (2011) found that a substantial proportion (<70%) of French agricultural (grassland and cropland) topsoils are under-saturated with carbon to some extent. Wiesmeier et al. (2014), in a study of Bavarian soils, found that about 400 Mt CO_2 equivalents could be theoretically stored in the upper layer of cultivated soils – four times the annual emissions of GHGs in Bavaria. Recent work has shown that the SOC concentrations of Irish mineral grassland soils range from 3.2 to 6.3% (Kiely et al., 2010; Xu et al, 2011). Furthermore, this group has found in a survey of Irish soils that 29 of the 36 sites examined are currently under-saturated in carbon. This suggests that Irish soils may have a significant carbon deficit, with potential for additional carbon to be stored. Furthermore, there is greater potential for C sequestration at greater soil depths than at a shallower soil layer. However, some studies have found soil carbon losses over recent time (Bellamy et al., 2005).

A review by Conant (2010) examined the grassland management practices (Allard et al., 2007) that enable soil carbon sequestration and demonstrated that many management techniques intended to increase livestock forage production also have the potential to augment soil carbon stocks, including fertilization (Fornara et al., 2011, 2013), irrigation, intensive grazing, rapid incorporation of manure and the sowing of favourable forage grasses and legumes.

While the research on grassland soil carbon is indicating sequestration, some questions remain and therefore MRV requires further research before Ireland can fully exploit its large land area for grassland carbon sequestration. MRV requires a national effort of soil carbon monitoring across the country, for a period of years, to record the inter-annual changes to soil carbon and to verify the quantity of carbon sequestered for a wide range of Irish soil types and grassland land management practices (Emmett et al., 2010).

The EU is now committed (EU Summit 23/24 Oct 2014) to examine methods for regulating Land Use, Land Use Change and Forestry to, amongst other options, increase carbon sequestration in grasslands and incorporate this in national GHG budgets. To gain the benefits of this, the Irish funding agencies (eg. the EPA and SFI) must urgently enable further independent scientific studies to strengthen the observations in this Royal Irish Academy Statement.

References

Allard, V, Soussana, J-F, Falcimagne, R, Berbigier, P, Bonnefond, JM, Ceschia, E, D'hour, P, Henault, C, Laville, P, Martin, C and Pinares-Patino, C (2007). The role of grazing management for the net biome productivity and greenhouse gas budget (CO_2, N_2O, and CH_4) of semi-natural grassland. Agriculture Ecosystems and Environment 121:47–58.

Angers, DA, Arrouays, D, Saby, NPA and Walter, C (2011). Estimating and mapping the carbon saturation deficit of French agricultural topsoils. Soil Use and Management 27:448–452.

Bellamy, PH, Loveland, PJ, Bradley, RI, Lark, MR and Kirk, GJD (2005). Carbon losses from all soils across England and Wales 1978–2003. Nature 437:245–248.

Byrne, KA, Kiely G and Leahy P (2007). Carbon sequestration determined using farm scale carbon balance and eddy covariance. Agricultural Ecosystems and Environment 121:357–364.

Beare, MH, McNeill, SJ, Curtin, D, Parfitt, RL, Jones, HS, Dodd MB and Sharp J (2014). Estimating the organic carbon stabilization capacity and saturation deficit of soils: a New Zealand case study. Biogeochemistry 120:71–87.

Conant, RT (2010). Challenges and opportunities for carbon sequestration in grassland systems. A technical report on grassland management and climate change mitigation. Prepared for the FAO. Integrated Crop Management Vol. 9-2010.

Emmett, BA, Reynolds, B, Chamberlain, PM, Rowe, E, Spurgeon, D, Brittain, SA, Frogbrook, Z, Hughes, S, Lawlor, AJ, Poskitt, J, Potter, E, Robinson, DA, Scott, A, Wood, C and Woods, C (2010). CS Technical Report No. 9/07 Soils Report from 2007 Centre for Ecology & Hydrology

Environmental Protection Agency (2013). Ireland's Greenhouse Gas Emission Projections 2012–2030. EPA, Johnstown Castle, Co. Wexford.

EUROSTAT (2012). Land cover, 2012. LUCAS2012.png. http://ec.europa.eu/eurostat/statistics-explained/images/8/8f/Land_cover%2C_2012_LUCAS2012.png

Feng, W (2012). Testing the soil carbon saturation theory: maximal carbon stabilization and soil organic matter stability as a function of organic carbon inputs. University of Pennsylvania.

Feng, W, Plante, A and Six J (2013). Improving estimates of maximal organic carbon stabilization by fine soil particles. Biogeochemistry 112:81–93.

Fornara, DA, Banin, L and Crawley, MJ (2013). Multi-nutrient vs. nitrogen-only effects on carbon sequestration in grassland soils. Global Change Biology 19:3848–3857.

Fornara, DA, Steinbeiss, S, McNamara, N, Gleixner, G, Oakley, S, Poulton, PR, Macdonald, AJ and Bardgett, RD (2011). Increases in soil organic carbon sequestration can reduce the global warming potential of long-term liming to permanent grassland. Global Change Biology 17:1925–1934.

IPCC (2014) Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Jones, MB and Donnelly, A. (2004). Carbon sequestration in temperate grassland ecosystems and the influence of management, climate and elevated CO_2. New Phytologist 164:423–439.

Kiely, G, Leahy, P, Lewis, C, Xu, X, Zhang, C, He, Y, Dao, L, Golden, N, Zi, T and Albertson, J (2013). Interactions of soil hydrology, land use and climate change and their impact on soil quality (SoilH). EPA, Johnstown Castle, Co. Wexford.

Kiely, G, McGoff, NM, Eaton, J and Leahy, P (2010). Soil C – Measurement and Modelling of Soil Carbon Stocks and Stock Changes in Irish Soils. EPA, Johnstown Castle, Co. Wexford.

Lal, R (2004). Soil carbon sequestration impacts on global climate change and food security. Science 304:1623–1627.

McBratney, AB, Stockmann, U, Angers, D et al. (2014). Challenges for Soil Organic Carbon Research. International Union of Soil Sciences Global Soil Carbon Conference, Madison, WI, USA.

Qin, Z, Huang, Y and Zhuang, Q (2013). Soil organic carbon sequestration potential of cropland in China. Global Biogeochemical Cycles 27:711–722.

Soussana, JF, Allard V., …Jones M.,…Valentini. (2007). Full accounting of the greenhouse gas (CO_2, N_2O, CH_4) budget of nine European grasslands. Agriculture, Ecosystems and Environment 121:121–134.

Wiesmeier, M, Hübner, R Spörlein, P Geuß, U Hangen, E Reischl, A Schilling, B von Lützow, M and Kögel-Knabner, I (2014). Carbon sequestration potential of soils in southeast Germany derived from stable soil organic carbon saturation. Global Change Biology 20:653–665.

Xu, X, Liu, W, Zhang, C and Kiely, G (2011). Estimation of soil organic carbon stock and its spatial distribution in the Republic of Ireland. Soil Use and Management 27:156–162.

Royal Irish Academy
19 Dawson Street
Dublin 2
D02 HH58

info@ria.ie
00 353 (0) 1 676 2570

www.ria.ie