Scotland's centre of expertise connecting climate change research and policy

Workshop Summary
Workshop on carbon sequestration in grassland
Thursday 7 November 2013

Aim

This stakeholder workshop was held to address the topics surrounding carbon sequestration in agricultural soils and how soil carbon could be included in whole-farm carbon accounting. The aim was to look at what is known, drawing on the research that has taken place in Scotland and referencing work undertaken elsewhere.

The genesis of the workshop was an article published by Quality meat Scotland and commissioned from Dr Jimmy Hyslop of SRUC that looked at carbon sequestration on permanent pasture. In that context it was felt that a wider discussion would be useful on the way we consider soil carbon sequestration or emission in the context of climate policy.

This document provides a summary of the key issues identified by workshop participants.

Background and introduction

Introduction and policy context
Antje Branding, Scottish Government

The main driver for the meeting is set by the Climate Change Scotland Act which sets emission reduction targets overall for 2020 and 2050 of and 80% respectively. These targets require a land-use strategy that has an influence on emissions from agriculture. Agriculture accounts for 20% of Scotland's emissions of which N_2O emissions are the largest source. Soil emissions are accounted for in agriculture, but not land-use change. There are no sectoral targets; just national targets. There are large error bars on the projections for agricultural emissions. This means that we need to be flexible and as we refine our knowledge we need to refine predictions. We need to understand that the way to achieve targets is not to reduce production but to reduce emissions per unit of production. Do we have enough knowledge about the gains and losses of carbon in soils to incorporate into on-farm carbon calculators? Is trading of soil carbon possible?

Participant Contributions

Carbon Sequestration: an Irish perspective on policy and science
Gary Lanigan, Teagasc, Ireland

Agriculture in Ireland contributes 1/3 national GHG emissions and is forecast to rise to 48% by 2020 due to planned expansion of industry. Before 2008 the emphasis was on cutting emissions through shifting out of grassland. The last few years have seen a fall in emissions. There is a new emphasis on efficiencies from 2010 – no longer on absolute emissions and food production targets. Offsetting via sequestration is currently seen as a way to balance the increased emissions from increasing dairy and sheep numbers. There are two separate targets: a high non-ETS target for GHG reduction but also increased value and production targets for food. The challenge is how to achieve carbon neutrality in farming. This is planned for delivery through sequestration in pasture and forestry. Forestry (due to planting dates) is due to be a net emitter by 2020 so grassland will have a very key role to play. There is a focus on ecosystem productivity accounting and carbon footprinting of agricultural products. The important thing is not to just look at carbon fluxes, but also the other inputs and outputs and stocks in the soil.

A soil survey of 120 sites has shown no net increase of carbon stocks in grassland, however there is no good record of grassland management practices between the site surveys.

Going forward the issue is how to increase agricultural production without increasing emissions. There is a lot of faith being placed in being able to offset GHG emissions through grassland soil carbon sequestration. It may lead to different agricultural strategies for different soil and climatic conditions.

Ireland will aim to develop land-use factors for grassland and cropland across a range of soil types, quantify management strategies for additional carbon sequestration, assess future climate change effects on sinks and will elect restoration of wetlands for Article 3.4.

Farm Carbon Management
Phil Thomas, QMS

The context of debate is world population growth and, as wealth grows, consumption per capita growth. Food security defines access to an adequate diet of choice. Agriculture is not entirely driven by public sector policies – supermarket purchasing plays a significant part. Food prices have risen significantly since 2008 and policies working against price trends will be difficult to sustain.

Farmers are traditionally slow to adopt. Their main drivers are regulation, funding incentives and technical improvements.

Statistics on the NH_4 (Ammonium) outputs from protein production when expressed in terms of emissions per kg hide the advantages of extensive beef and lamb production. A Dairyco study of farms in England and Wales showed that efficiencies increase with high yields and carbon emissions per kg go down but with a very high variation between farms. One approach is to tackle ammonia release which is hard to do in extensive systems – it is easier to control feed in an intensive system. Good breeding and husbandry can reduce NH_4 rates by 33%. QMS are interested in whether a farm business in total could be carbon neutral, and in particular can this be achieved in extensive grazing systems. If flux measurements suggest that sequestration of 1 t/ha can be achieved, is this an actual sequestration rate? If you can include the sequestration on land not actively farmed in calculations then extensive farming systems could look better than intensive on a per kg basis.

Difference between carbon sequestration and carbon stocks
Pete Smith, University of Aberdeen

Soussana et al. (2007) estimated a mean European grassland carbon sequestration rate (average of 9 CarboEurope sites) of 74 g C m-2 yr-1 (= 0.74 t C ha-1 yr-1). Net Carbon Storage is given by NCS = $(F_{CO2} + F_{CH4\text{-}C} + F_{VOC} + F_{fire}) + (F_{harvest} + F_{animal\ products} – F_{manure}) + (F_{leach} + F_{erosion})$. Flux measurement is only $F_{CO2.}$

A study by Bellamy et al. (2005) of gridded resampling of soils across the whole UK, measured no gain in soil carbon over 25years. Long term Newcastle + Rothamsted sites (2009) showed no change to soil carbon in grassland over 100+ years. If there was continuous accumulation of carbon over time soils would have higher carbon levels. The question is, what are the on-going carbon sequestration rates?

Grassland can sequester carbon on change of land use or improved management of stocks. This is not a long term trend but amounts to about 0.2 t ha^{-1} over 20-30 years. After 100 years soils will reach a new equilibrium.

Carbon prices: restoration to grassland has a high potential at low carbon prices (since it is inexpensive to do) but as the carbon price increases more expensive options which have greater per area potential to increase carbon (such as peatland restoration) are favoured.

Conclusions: Grasslands under constant management do not sequester carbon. Apparent carbon sequestration in grasslands measured by eddy covariance (flux) could be due to incomplete carbon accounting, or could be measuring an increase due to land use or land management change legacy effects. High carbon stocks do not equate to high rates of carbon sequestration - business as usual does not sequester carbon.

Policy implications: Protect the high carbon stocks in grasslands, and if management is suboptimal, improve it to sequester carbon. Pete Smith has since prepared a paper based on this presentation which will soon be published in Global Change Biology, and is available on the website as an "advance online" publication (Smith, P. 2014. Do grasslands act as a perpetual sink for carbon? *Global Change Biology* (in press). doi: 10.1111/gcb.12561.)

James Hutton Institute work on soil inventories
Allan Lilly, JHI

A National Soils Inventory was sampled on a 10km grid between 1978 and 1988 and 25% of these locations (20km grid) were revisited between 2007 and 2009 and the soils at these sites resampled. Changes over the 20-30 year time period showed no overall changes in carbon stocks. Improved grassland showed a decline in carbon stocks (4.5 t ha^{-1}) that was not statistically significant whereas woodland soil showed a significant increase in carbon stocks. There was a significant loss in the proportion of soil carbon from grassland soils but this apparent contradiction could be accounted for µµby deeper ploughing that increased the thickness of the topsoil but diluted the carbon content by incorporating subsoil.

Further calculations based on empirical modelling using the equation developed by Hassink (1997. The capacity of soils to preserve organic C and N by their association with clay and silt particles. Plant and Soil, 191, 77-87. DOI:10.1023/A:1004213929699), who related soil sequestration potential to the proportion of mineral particles less than 20µm, suggest that the carbon content of Scottish topsoils already exceeds their capacity to sequester carbon long term. However, work by Lilly and Baggaley (2013. The potential for Scottish cultivated topsoils to lose or gain soil organic carbon. Soil Use and Management, 29, 39-47. DOI: 10.1111/sum.12009) shows that there is scope for further storage of carbon in Scottish soils although this carbon is more labile and potentially vulnerable to loss. .

There is no evidence that mineral soils continue to accumulate carbon to become carbon rich or humose, though defining an upper limit of carbon stored is difficult. The carbon that is sequestered or stored tends to be near the surface and therefore most vulnerable to loss from the soil. This is especially true of organo-mineral soils with a peaty surface layer.

Flux measurements (Easter Bush work)

Ute Skiba, SRUC

This project consisted of a study of 2 x 5 ha fields at Easter Bush, Midlothian. Towers were used to measure gases using eddy covariance measurements of net ecosystem exchange of CO_2. Two soil samples on 20m grid 7 years apart used to measure soil carbon.

The flux measurement suggests a net carbon sequestration rate of 221.2 g C m^{-2} y^{-1}. The change in carbon stock is less than the uncertainty in the stock change method, and there is no net change measured. It was therefore concluded that there is no change in soil carbon at Easter Bush.

Conclusions: Intensively managed grazed grasslands are a net source of nitrous oxide from soil and methane from ruminants, but it is unlikely that these emissions are off-set by carbon sequestration. Ploughing the Easter Bush field did not lead to large CO_2 or N_2O losses.

Issues for further research: Can we reduce soil N_2O and CH_4 emissions by improved drainage or regular ploughing? How much carbon is lost through ploughing? Do managed grasslands sequester carbon?

Effect of Land Management Practices on Carbon Soil Stocks Under Grassland
Janet Moxley, CEH
Report on DEFRA project SP1113:

Objectives:

- To assess the feasibility of including changes in soil carbon stocks due to cropland and grassland management in the UK's LULUCF inventory (for reporting in the 1990-2013 inventory in 2015)
- To improve assessment of progress on GHG targets
- To identify knowledge and information gaps
- To quantify the effect of land management policies in the inventory
- To have projections to 2020 and 2050 to test the impact of policies for mitigation and other ambitions

Outputs:

- Operational method for estimating soil carbon stock changes from grassland and cropland management for the LULUCF inventory
- Compilation of activity data and Tier 1 and 2 emission factors for reporting 1990-2010
- Business-as-Usual and mitigation policy scenarios to 2020 and 2050 to assess the mitigation potential and interacting impacts in different regions of the UK

Findings from the literature review:

- There is limited UK-relevant literature for most practices;
- the largest effect on soil carbon is likely from increased inputs, although less clear for grasslands than croplands;
- a rotation pattern in grass leys will affect soil carbon stocks.

The key findings from an international comparison (NIRs from 11 countries reviewed) were:

- There is a range of methodologies used including data returns, remote sensing/aerial photography and modelling;
- There are different approaches used for mineral and organic soils. Reporting is limited by lack of activity data;
- Denmark use LPIS data grazing and other grassland (heath) with C-Tool model addressing both mineral and organic soils.

- Portugal's system is based on LPIS data and country-specific emission factors on mineral soils only.

Reduced emissions are explained as a net effect of land use change, not a land management effect i.e. more conversion of cropland to grassland than grassland to cropland.

Soil carbon trading
Andy Kerr, ECCI

Carbon trading is an alternate policy tool to taxation or sector-based regulation for reducing pollution (in this case greenhouse gas emissions). The primary approach is through a "cap-and-trade" system, through which a national or international authority creates a quantity cap on the target emissions – by creating a fixed number of tradable allowances - and then reduces this quantity of allowances through time. Participants must match their annual pollution with the appropriate number of allowances and surrender these allowances to the authority each year. There is no cap on individual participant emissions, but collectively all participants are constrained by the total quantity of tradable allowances in circulation. The other main approach is known as a "baseline-and-credit" system. This works by offering a credit – which has a financial value and can be traded - for action undertaken in an emission reduction project; it always relies on an estimate of the counterfactual "what would have happened in the absence of the project". Measurement and monitoring is inherently more uncertain than for a cap-and-trade scheme.

At the heart of any carbon trading scheme is the requirement that emissions from different participants must be equivalent: 1 tonne carbon emitted by one participant in one place must equate exactly to 1 tonne emitted by another participants in another place. As a result, detailed monitoring and auditing of emissions underpins all carbon-trading schemes. Typically, auditing of emissions is forensic; is undertaken by third parties and checked by competent authority. There is always a trade-off between the costs of verification and auditing and the accuracy with which emissions are monitored and measured. Where the costs of monitoring and measuring are disproportionately high, other simpler policy tools may be more appropriate. Unless the processes that cause emissions are very complicated, carbon-trading schemes do not typically measure "stack measurements" – emissions outputs from the process. Instead they measure inputs (e.g. amount of fuel combusted; or amount of cement produced) and calculate the emissions based on the calorific value of the chemical reaction (tonnes CO_2/tonne carbon content of fuel).

For the carbon market to work there must be willing buyers. This is most easily achieved by the authority ensuring a shortage of allowances in a cap-and-trade system. For a baseline-and-credit scheme, finding willing buyers relies on the level of trust in the veracity of the monitoring and measurement system. The forestry sector, which was an early mover in carbon trading, suffered because of the lack of trust in the systems for measuring, monitoring and verifying the claimed carbon benefits. More recent schemes (Woodland Carbon Code; Verified Carbon Standard) are now creating more consistent methodologies in place to address this mistrust.

Soil carbon trading is still at an early stage, but examples of robust methodologies for measuring and monitoring soil carbon are being developed in Australia, New Zealand, US and elsewhere. These typically rely on measuring soil carbon at a particular depth and averaging over particular soil types and land use units. Actions to enhance soil carbon are undertaken through land management practices (increasing plant biomass production; decreasing loss of organic matter; reducing soil disturbance).

The value of a soil carbon trading scheme will depend on the costs of monitoring and measuring of soil carbon not being prohibitively high; in other words, robust methodologies for monitoring, measuring and verifying soil carbon through time must be commensurate with the likely carbon value gained through soil carbon trading.

On-farm carbon calculators
Allan Lilly, JHI and Bob Rees, SRUC

Carbon calculators can make a quick assessment of emissions from a farm and compare it with benchmarks. Farmers can use the tools to make decisions that lead to improved emissions and efficiency. As such, they can allow farmers to identify opportunities for improvement.

However, emission factor calculations come with considerable uncertainties, input data requirements are demanding and time consuming and differences in allocations and boundaries result in differences between tools.

Attendees

Antje Branding , Scottish Government
Gary Lanigan, Teagasc
Phil Thomas, QMS
Pete Smith, University of Aberdeen and ClimateXChange
Matt Ogston, ClimateXChange
Andy Kerr, ECCI, University of Edinburgh and ClimateXChange
Allan Lilly, JHI
Bob Rees, SRUC
Kairsty Topp, SRUC
Janet Moxley , CEH
Rebecca Audsley, SRUC
Carole Stewart, Scottish Government
Judith Stuart, DEFRA
Karen Dobbie SEPA
Graham Kerr, SAC Consulting
Kim Matthews, Eblex
Robert Ramsay, Soil Essentials
Ute Skiba, SRUC
Catherine Armstrong, RSPB
Francis Brewis, Scottish Government
Robin Matthews, JHI
Jim McLaren, QMS