RURAL POLICY CENTRE
RESEARCH BRIEFING
Supporting the land-based industries for over a century
SAC

Carbon footprint reporting for a Scottish livestock farm

Kairsty Topp[1] and Bob Rees[2]

QMS QUALITY MEAT SCOTLAND

Introduction

As the impact of agriculture on climate change is increasingly recognised, carbon footprinting has risen up the agenda. Some producers are seeking to find out about their carbon footprint because increasing consumer awareness of the carbon emissions associated with food production and supply could influence consumer behaviour. Yet while carbon footprinting has become a commonly used term, confusion can arise from the different methods used to calculate it. This project aimed to (1) better understand the carbon footprint of a livestock farm in Scotland and to report baseline data against which changes in emissions could be assessed; and (2) compare the outputs of different footprinting tools.

What we did

The study farm was in NE Scotland with an area of 457 ha. The farm was managed on two different sites. The largest unit, Site 1, was an area of 142 ha of rotational grass and cereals in which grass was grown for three years, followed by three years of a cereal crop (mostly spring barley). The grass received fertiliser applications of 215 kg N/ha annually, split between ammonium nitrate based fertiliser (140kg N/ha) and urea (75 kg N/ha). At Site 1, there were also areas of permanent grass (92 ha) and grazed woodland (61 ha). Site 2 was split between rough grazing (81 ha) and grazed woodland (81 ha). The farm was stocked with approximately 300 cattle (distributed between Sites 1 and 2) and 355 over-wintering sheep, which were located on the rotational grass at Site 1.

Calculating the carbon footprint – The carbon footprint was determined using two contrasting models (IPCC[3] and DNDC[4]). The IPCC model calculates emissions and sequestration of greenhouse gases from agricultural systems in accordance with IPCC's 2006 guidelines and uses relevant UK emission coefficients where appropriate. The DNDC (ver 92) model is a systems-based mechanistic model that simulates carbon and nitrogen flows in agricultural ecosystems. It is widely acknowledged as a state-of-the-art model for use in assessing nutrient fluxes in arable farming systems. Farm management data was provided by the farmer and climate data for a period between 1992-2006 was obtained from a weather generator.

What we found

This research found that the farm is in an approximate carbon balance, with the processes releasing carbon into the atmosphere roughly balanced by processes that remove carbon and store it in the soil and vegetation. An analysis of the data shows that the processes contributing to carbon release (expressed as carbon equivalents) were livestock, fertilisers and manure use, and fuel (Figure 1). The process largely responsible for removal of carbon from the atmosphere is plant growth. On this particular farm, a significant area of woodland was particularly important in contributing to carbon uptake. Trees remove carbon dioxide from the atmosphere and transfer this carbon to the soil resulting in a slow build-up of carbon in the soil. This then counterbalances carbon release from other processes.

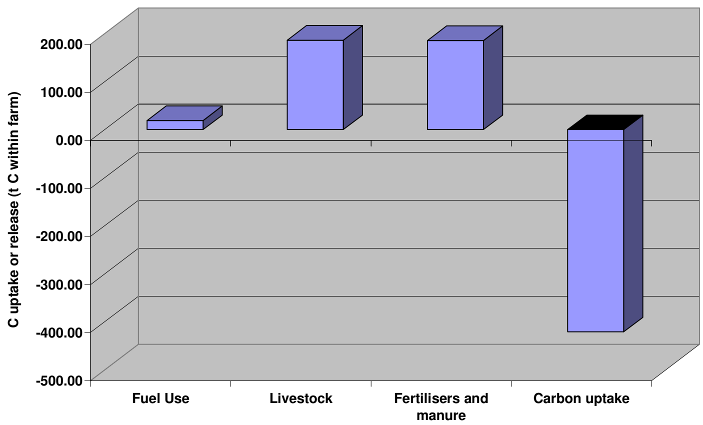

Figure 1: Overall carbon budget for the farm (Sites 1 & 2) calculated using IPCC's approach. There was a small net overall uptake of 5 t C per year.

[1] Scottish Agricultural College, West Mains Road, Edinburgh, EH9 3JG. Tel. 0131 535 4026. Email: kairsty.topp@sac.ac.uk.
[2] Scottish Agricultural College, West Mains Road, Edinburgh, EH9 3JG. Tel. 0131 535 4365. Email: bob.rees@sac.ac.uk.
[3] Intergovernmental Panel for Climate Change
[4] DeNitrification and DeComposition

The major contributions to carbon emissions were made by livestock and fertiliser and manure use (livestock emit carbon in the form of methane). The suckler cow herd on this farm was responsible for the largest proportion of emissions contributing a total of 111 tonnes of carbon per year. Fuel use on farm contributes a relatively small proportion of the total carbon budget (thus reducing fuel use will have a small impact on the carbon budget).

Fertiliser use contributed to the carbon budget of the farm through the production of nitrous oxide, which is produced from soils when the nitrogen concentration is raised through the addition of fertilisers or manures. It is more likely to be produced when high soil nitrogen concentration coincides with periods of soil wetness. Emissions of nitrous oxide are therefore also highly variable depending upon weather conditions at the time of fertiliser use. Within this study, emissions were concentrated in the areas of the farm that received the highest nitrogen applications. These were the cereal-grass rotation, and the more intensively managed grasslands. In these areas, emissions of nitrous oxide could be as high as 10 kg of N per hectare per year. Although this seems a relatively small loss of nitrogen, nitrous oxide is a powerful greenhouse gas, with a warming effect which is 310 times stronger than that of carbon dioxide. Thus, 10 kg of nitrous oxide is equivalent to 3100 kilograms of carbon dioxide.

Detailed modelling work showed that crop and fertiliser management also had an important impact on the carbon budget. The grassland and woodland soils were shown to contribute to an uptake of carbon from the atmosphere. This uptake was greatest in the woodlands and varied from year to year according to annual variability in weather, with annual accumulation of carbon in the soil of between 1000 and 2000 kg per hectare.

Different approaches to measuring carbon footprints

Two approaches, IPCC and DNDC, were used to calculate the carbon budget of the farm used in this study. The standard IPCC approach provided similar overall estimates of the carbon budget to a more detailed modelling approach using the process based model called DNDC. Some differences were however apparent (Figure 2). The DNDC model was unable to simulate methane emissions from livestock, so these were calculated only using the IPCC approach. Estimates of nitrous oxide emissions from fertilisers/manures were larger using DNDC, and carbon uptake were slightly lower. The two approaches have different advantages and disadvantages. An advantage of the IPCC approach is that it follows a widely recognized methodology, and is able to account for all carbon flows on the farm. However, it does not provide a very detailed analysis of the origin of the carbon fluxes and is unable to take account of the effect of subtle changes in management or weather. DNDC, by comparison, is able to provide a detailed analysis of the origin of carbon fluxes, and is therefore potentially helpful in designing management to reduce the footprint.

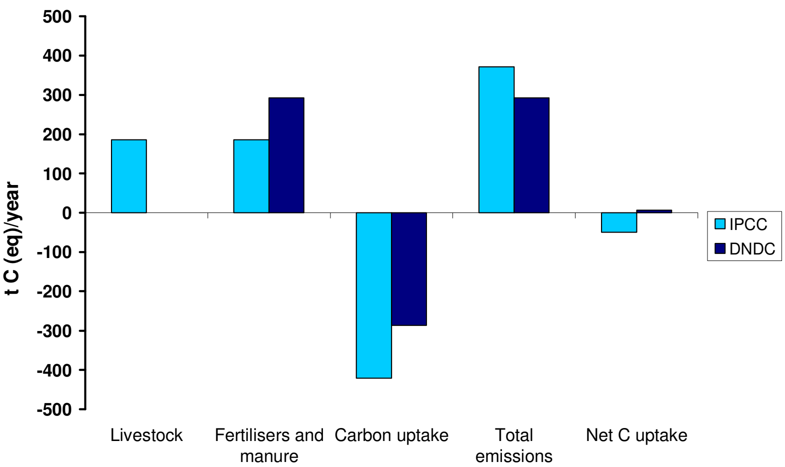

Figure 2: A comparison of the two modelling approaches used to calculate greenhouse gas emissions. The comparison does not include methane emissions from livestock as it is not included in the DNDC model. Positive values represent emissions and negative values uptake (removal) of C.

Implications for Management

This study highlights the importance of biological processes in the carbon budget of farming enterprises. In order to reduce the carbon footprint it is necessary to minimise emissions and maximise carbon uptake.

Large reductions (40-80%) could be achieved by:	Smaller improvement (20-40%) would be possible by:
• Planting more trees • Reducing animal stocking rates • Reducing fertiliser N application rates	• Altering animal diet/breeds • Increased N uptake efficiency • Improved manure management • Improved cultivation practices (minimum tillage, one-pass)

An advantage of the second group of management changes is that they also contribute to a more efficient, and possibly more profitable, farming enterprise. A clear difficulty with the first category of changes is that there is a conflict between the need to reduce the farm's carbon footprint and the need to maintain productivity.

The authors are grateful to QMS for funding this work and to the farmer for provision of data and support for the project. This briefing was prepared by Andrew Midgley, Rural Policy Centre.