Using values economics to add mitigation of greenhouse gases to dairy selection tools

E Wall, D Moran
SAC, Edinburgh, United Kingdom
Email: eileen.wall@sac.ac.uk

Introduction The economic appraisal of greenhouse gases (GHG) emissions is complex. The shadow price of carbon (SPC) is derived from the best estimate of the present value of damages associated with a tonne of GHG emission in carbon dioxide equivalents (CO_2 eq). The SPC rises with time, reflecting the increasing marginal damage of a tonne of GHG when added to a growing stock of atmospheric GHGs. There are many possible technical mitigation options for livestock systems, one of which includes harnessing selection tools. The study of Stott *et al*. (2005) describes how relative economic values (REVs) are calculated for traits included in the UK dairy profit index (£PLI) using dynamic programming tools to model a whole farm system. The REV for each trait is calculated by examining the consequence of a unit change in a trait of interest on net farm revenue, while keeping all other traits in the index fixed. The SPC provides a useful mechanism of considering the costs of GHG emissions in an economic index framework, such as £PLI. This study outlines methods for incorporating the environmental value of emissions mitigation into breeding goals.

Materials and methods The model parameters used by Stott *et al*., 2005 and IPCC Tier II methodologies (IPCC, 2006) were used to model the methane, CH_4 (enteric fermentation and manure storage), and nitrous oxide N_2O (manure storage) emissions from the whole farm system (young stock and milking herd) used to calculate REVs for £PLI. The N_2O emissions due to nitrogen excretion when cows are grazing were also included. The shadow cost to the dairy herd of GHG emissions was calculated by multiplying the current value of the SPC (2008 value = £26.50/t CO_2 eq) by the total GHG emissions from the system. The REV considering the SPC for milk yield was then calculated by increasing milk yield in percentage units while holding all other traits fixed. The impact of improving milk yield on GHG emissions and therefore the overall shadow cost of emissions to the farm is that fewer cows and followers are required to maintain a fixed herd output.

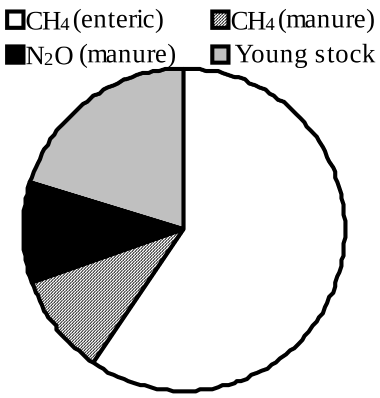

Figure 1 CH_4 and N_2O emissions from the milking herd and young stock expressed in t CO_2 eq for a defined dairy

Results Figure 1 shows that the largest proportion of GHG emissions from the defined dairy system is due to enteric fermentation in the milking herd, with over 59% of the total GHG emissions. The young stock contributed over 20% of the total GHG emissions, which included CH_4 from enteric fermentation and CH_4 and N_2O from manure storage. Overall, the dairy system produced approximately 791 t CO_2 eq per annum. This equated to annual shadow cost to the dairy herd of £20 957 per annum or 1.95 p per kg milk produced. Improving milk yield by 1% decreased the GHG emissions from the dairy system by 4.8 t CO_2 equivalent. This resulted in a new annual shadow cost to the dairy herd of approximately £20 830 per annum (or 1.94 p/kg milk) a reduction of £127 per annum. The SPC REV for milk yield was calculated to be £0.012 per kg of milk per cow per annum, or £3.64 per genetic standard deviation unit. Adding this to the current £PLI would result in a relative weight in the index of 6% compared to the other production and functional traits already incorporated in £PLI.

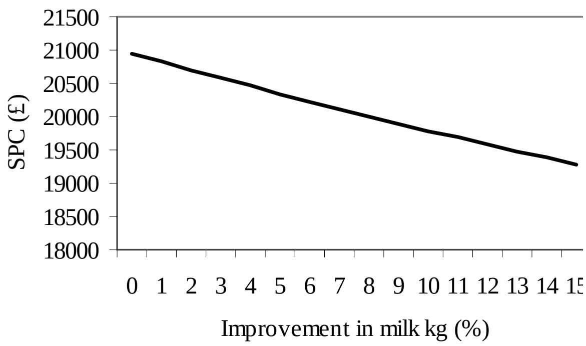

Figure 2 Shadow price of carbon (SPC) to the herd in £GBP per annum when milk yield is improved.

Conclusions This example shows a method by which a non market or shadow environmental value can be incorporated into selection indices using increased milk yield to reduce the herd size required to maintain herd output as the goal trait. A similar framework could be applied to other traits under selection to estimate a new suite of REVs that consider combinations of market and non market traits (positive and negative). Note also that many of the other traits included in £PLI, such a lifespan and health and fertility traits, will have an additional favourable impact on GHG emissions by improving overall system efficiency.

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References

IPCC 2006. Guidelines for National Greenhouse Gas Inventories.
Stott AW, Coffey MP and Brotherstone S, 2005. Animal Science 80: 41-52.