BACK TO THE FUTURE?
Reconnecting land and livestock

Introduction

The widespread reintroduction of crops and livestock could make a major contribution to the development of the wider EU circular (agricultural) economy and contribute to sustainable growth, through the more effective recycling of materials and resources, the minimization of waste, and a reduction in external supplies of feed and synthetic fertilizers, with potential biodiversity, environmental and soil health benefits. However, this comes with significant challenges, including the potential for enhanced greenhouse gas (GHG emissions), particularly methane (CH_4) emissions, from enteric fermentation, land degradation, due to overgrazing and water pollution, as well as the need to effectively substitute all/most inorganic fertilizers with organic manures. Organic amendments applied to land could conversely result in enhanced GHG emissions, particularly nitrous oxide emissions, unless these are managed appropriately and the necessity to store large amounts of organic manures/wastes may also be problematic, given their links to environmental pollution and GHG emissions. Additional complications could arise due to associated modifications in land use, including a shift from a grass-based to a forage/alternative crop-based diet, altered grazing practices and increased competition between food and animal feed, or the use of biogas or bioenergy crops. Whilst mixed farming systems were previously common and economically viable, they will need to be matched to current production and market conditions to ensure their long-term viability. To address these issues, as part of the ReLIVE project *(Reintegration of land and livestock for GHG mitigation and circularity)* [*], we have assembled a multi-actor inter-disciplinary research team, with wide-ranging expertise in the animal-crop supply chain and its environmental impact.

The ReLIVE Project

Background

Livestock have always made an important contribution to farming, since at least Roman times, when there was also some limited form of crop rotation. Mixed farming systems became an integral part of the managed landscape in Europe with the development of the Norfolk four-course rotation, involving the growth of turnips, clover, wheat, and barley. Livestock were not only a source of food and income, but they were also a key component of the system enabling the recycling of crop biomass and associated residues, and providing the organic fertilizers, that were used to support crop growth. The Norfolk four-course and other crop rotations were used largely unchanged until the 1960's when the introduction of relatively inexpensive fertilizers removed the need for livestock manure and increased specialisation, based largely on economic objectives, resulting in a focus on a limited number of crops. This has, however, resulted in increasing environmental concerns associated with the excessive use of inorganic fertilizers that have led to an increase in nitrous oxide (N_2O) emissions, nutrient (N and P) leaching, and the reduced resilience of a system focussed on one or more specialised crops.

The decoupling of crop and livestock production and the increased adoption of specialized farming systems focussed on a limited number of crops is often considered to underpin many of the undesirable social and ecological effects of agriculture. It is increasingly recognised that the re-introduction of livestock into farming systems could potentially address some of these issues, without compromising yields, if the associated challenges associated with modern-day agricultural practices, can be addressed. Improving and sustaining the livestock sector is also critical for addressing many of the Sustainable Development Goals (SDGs) of the United Nations. Improved circularity will also contribute to the implementation of EU goals on the new 2020 Circular Economy Action Plan. Strong synergies also exist with the EU's objectives on climate and energy and sustainability, particularly the sustainability goal 12 'responsible consumption and production'. However, the older mixed farming and agroforestry systems were developed without the full recognition of their environmental consequences, or their benefits. Today, a major challenge is to develop and maintain agroecosystems with a minimal environmental footprint. Perhaps one of the biggest challenges faced in the RelIVE project (Fig. 1) centres around the high levels of CH_4 emitted by ruminants. However, the wider use of manure as a source of fertilizer could significantly reduce GHG emissions, particularly N_2O.

Livestock reintegration, GHG offsetting and circularity

Livestock could also have a significant role in addressing a major circularity issue, the effective recycling of farm wastes, as well as contributing to increased farm biodiversity. The question is, how can the negative aspects of livestock re-introductions be addressed, whilst also taking advantage of the positive aspects- self-sufficiency in fertilizer requirements, and increased grazing-related biodiversity and weed control? Whilst the emphasis in the ReLIVE project will be on reducing CH_4 emission, any direct or indirect effects on the other significant GHGs, CO_2 and N_2O, cannot be ignored. These must also be considered to ensure that any modifications that result in reductions in CH_4 emissions are not offset by increased emissions of CO_2 and/or N_2O.

Fig. 1. Reintegration of land and livestock for sustainable low input production systems with increased circularity and the effective recycling of organic wastes

Several approaches are envisaged that directly address a reduction in CH_4 emissions and GHG offsetting associated with livestock reintegration, including enhanced CH_4 oxidation and/or C sequestration in soils and biomass, while also reducing GHGs, particularly N_2O. For instance, some afforestation/agroforestry could reduce CO_2 emissions and enhance C sequestration without compromising N_2O emissions. Reductions in N_2O emissions may also be possible using organic fertilizers (slurry, manure, or compost), whilst direct reductions in CH_4 could be achieved through dietary changes or the increased soil sinks provided through afforestation or agroforestry. All of these will be considered within the project to maximise the efficiency of nutrient recycling through an examination of the soil-crop-residue-animal system.

Crop diversification and modelling

Within the ReLIVE project consideration will also be given to the diversification of cropping systems and the use of alternative crops and novel grazing options. Particular attention will also be directed at the role of soils as sinks for CH_4 and how this can be enhanced. New on-farm methodologies and approaches will be identified and tested that can verify the efficacy of a particular approach for reporting on the effect of alternative farming options. Feedback from stakeholders will be utilized to assess the benefits of any modifications and their practical implementation. Information from the data repository, together with new experimental information will be used to identify optimal strategies for reintegrating livestock into farming systems that minimize GHG emissions and enhance SOC stocks. To do this, we will develop a new model, HOLOS-EU, based upon the widely recognized Whole Farm Model "Holos" (Fig. 2), which has been tested recently as part of the GHG-Manage ERA-GAS project, and will be specifically tailored to European conditions through the updating of algorithms/sub-modules/interfaces. This will enable us to identify crop choices, and assess sustainability, and resilience in relation to productivity, climate change and economic factors. The utility of a widely used platform, the Cool Farm Tool (CFT), will also be examined to improve on-farm reporting of GHG emissions and SOC stocks and compared with Holos-EU for its wider applicability under EU conditions.

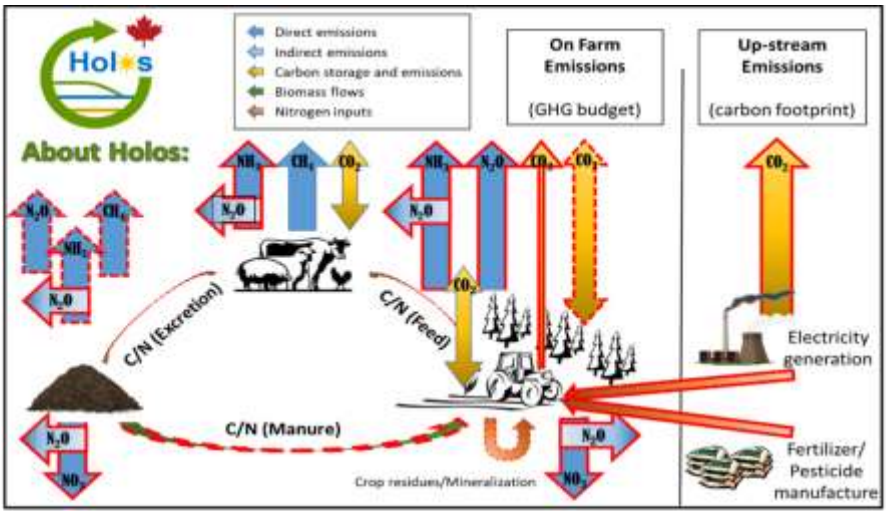

Fig. 2. Schematic diagram of the Holos Model (Canadian Version; Source: AAFC), which will be adopted for use under Irish/EU conditions

Overall project goals and stakeholder engagement

Particular attention will be directed at livestock type and management, the appropriate use and storage of manures, crop choice, including direct grazing of crops and/or their residues, the use of afforestation/agroforestry as an alternative grazing option, as well as how this information can be integrated into decision support tools for identifying the best options for farmers. Importantly, we will directly address how we can improve farm CH_4 budgets, through the use of alternative livestock dietary feed sources, coupled with novel investigations on a mechanistic assessment of the ability of soils to oxidise CH_4. Critical to this approach is an ability to monitor and validate the effect of management options on the net GHG budgets and their economic consequences, as well as the effective dissemination of the results for practical implementation by policymakers, stakeholders, farmers, and other end users. Stakeholder engagement will play an important role in realising the benefits of any modifications that are identified to both increase circularity whilst also minimizing the environmental footprint of mixed farming systems. In the end, we need to maximise the benefits of livestock reintegration, whilst avoiding any negative impacts, and provide practical information that can be effectively disseminated to farmers and other stakeholders.

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