Food, Farming & Countryside Commission

Devon Locally Led Inquiry

Grasslands and Livestock Production in Devon

RSA
21st century enlightenment

Contents

Thanks

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Preface

Launched in November 2017, the RSA Food, Farming and Countryside Commission is a major, two-year independent inquiry, funded by Esmée Fairbairn Foundation.

Chaired by Sir Ian Cheshire, with fourteen Commissioners from across sectors, the Commission is tasked with creating mandate for change across our food system, farming sector

and in rural communities; shaping a long term vision for the future that's fairer, stands the test of time and aligns more closely with changing public values and expectations; and propose solutions to achieve the vision, identifying where communities and businesses can take a lead and where a national policy framework is required.

Role of the locally led inquiries

The issues covered by the Commission are wide-ranging and heavily influenced by context. From policy differences in the Devolved Nations, to cultural and topographical differences across the countries, it was clear from the outset of the Commission that seeking local perspectives would be critical.

In England, the Commission sought to set up three locally led inquiries. These inquiries would create a frame for the counties of Devon, Cumbria and Lincolnshire to investigate the issues of the Commission most relevant to them, with the aim of stimulating local debate and informing the national Commission.

Devon's locally led inquiry was chaired by Commissioner and Devonian, David Fursdon, who convened a group of expert stakeholders from across food, farming, agriculture, conservation, policy and health, with members from Devon and neighbouring Cornwall. This Committee identified four key issues: Health and Thriving Communities; New Entrants; Devon's Grasslands, and Environment and Biodiversity. Each of these were explored by their own working group, chaired by a member of the Committee. Work took place between June 2018 and May 2019.

The Devon Committee were ably assisted by Professor Matt Lobley and Beth Dooley from the University of Exeter who acted as lead researchers and authors.

Each working group has produced a summary paper of their work, published in July 2019.

Next steps

The release of these papers coincides with the publication of the RSA Food, Farming and Countryside Commission's report Our Future in the Land. The insight from this working group has contributed to the body of evidence reviewed by the Commission and helped to inform their findings and recommendations.

The Commission runs until October 2019 and the next few months will see it work to bring its recommendations to life. This will include supporting the Devon Committee to publish a single report of their work and recommendations, designed to stimulate local action.

Key messages

- Grassland forms an important part of Devon's landscape for agriculture, the food industry and leisure and tourism
- Significant improvements are available in grassland production and utilization, which will lead to benefits in agricultural productivity
- Grassland farming enables non-human edible foods (ie grass) to become human edible through conversion into animal protein from agricultural land that cannot be used to directly produce human edible foods
- Meat from these animals has different nutritional compositions that may have less of an impact on human health than meat produced in grain-fed systems
- Agriculture has the unique ability to offset not only its own carbon production (principally through areas of grassland), but also contribute to wider carbon reduction targets
- Agriculture, while nationally small in its employment and output, is the basis for the much larger food industry and forms a vital part of local, regional and national identity, traditions and heritage, culture and the landscape
- There are significant gaps in our knowledge of how to optimally manage grasslands for the multiple functions they provide; thus, on-going research and knowledge exchange is vital

Introduction

Grasslands hold special significance around the world. They constitute rich landscapes, are embedded with cultural heritage, provide habitats for millions of soil microorganisms, insects, plants and animals. The terrestrial biosphere sequesters roughly 20-30 percent of anthropogenic CO2 emissions, referred to as a carbon sink affected by the counteracting fluxes of land use change resulting in release (eg deforestation to bare ground or the built environment) and CO2 absorption through photosynthesis and soil organic matter incorporation (Schimel et al., 2015; Arneth et al., 2017). Grasslands also provide a feed source for livestock, which on various land may be the most optimal form of vegetation to grow to efficiently produce food due to soil type and condition, rainfall, slope, availability of labour, mechanisation and fertiliser, etc (Soussana et al., 2010). Grasslands often grow in conditions where it would not be feasible to produce an alternative crop for direct human consumption.

Devon's geography and climate make it an especially good place to grow grass and less well suited to other kinds of food production, which is reflected in the description of its farming sector in the following sections.

However, like increasingly modernised technological production systems worldwide, the amount of people employed within the sector has decreased, which may lead to rural workers having to relocate to find jobs elsewhere. That may negatively impact rural economies and contribute to even fewer people understanding where their food comes from and what it takes to get it from the farm to their fork.

Additionally, climate change not only poses a risk of causing major losses in food production but is also heavily impacted by modern fossil fuel based systems of production from artificial fertilisers, emissions from livestock production, deforestation and disturbance of the terrestrial sink (Smith et al., 2014). Significant efforts to address the loss of farmland birds and insects contributing to the biodiversity of the land and soil must be undertaken, as well as carbon sequestration in the soil through reduced tillage, maintaining and increasing permanent pasture, and incentivising (re)planting of trees in parts of the landscape. Whilst it is not always the case that small farms are stewards of the land, Winter and Lobley (2016) found that small farms in certain locations, such as pastoral landscapes, are responsible for a significant proportion of the agriculture sector's conservation capital (Lobley, 2000). Thus, Devon's large number of small farm holdings on agriculturally improved grasslands have the potential to contribute further by improving conservation management and offering alternatives to emissions-intensive meat production, shorten the food supply chain to local / regional consumers, and support rural economies and communities (Lobley and Hopkins, 2006).

Flying the flag for grass

The South West holds special importance in the national farming landscape, comprising 20 percent of the farmed area (Defra, 2019a). In 2016, the total farmed area in the South West was just under 1.8 million hectares, with 49 percent (875,916 ha) of it under permanent pasture and 12 percent (216,744 ha) under temporary grass (ibid). Devon, the largest county in the South West, has 72.4 percent (485,751.5 ha) of its land under commercial farm holdings, of which over 75 percent are grasslands (ibid). Specifically, 311,949 ha are permanent grasslands and 64,122 ha are temporary, totalling 36 percent and 30 percent of those land-use types overall in the South West (ibid). Another 4 percent of Devon's farmed area is dedicated to sole-rights rough grazing1, which does not account for the additional commons area available on Dartmoor and Exmoor National Parks within the South West (ibid). Given such large-scale land cover, Devon's grasslands have the potential to produce over 6.6 million tonnes for grazing and silage per year, assuming average yields from an AHDB trial in Cornwall in 2016 at 16.6t dry matter (DM) per ha (the average for UK grasslands is 8t DM/ha) (AHDB, 2018a).

Given the soils predominantly covering the landscape and topography, grassland is an effective crop production choice well-suited to Devon. Much of the outer edges of the county are covered in soils with high silt and fine sand content or soils of the Slate Hills, which if left bare in heavy rainfall events may lead to capping (Smith, 2017, p. 18). Dartmoor and Exmoor are made up of either moorland soils that are well drained over permeable bedrock or slowly permeable layers at shallow depth, which causes the familiar waterlogging in the moors (ibid). East Devon's valleys and hill plateaus have clayey or loamy over-clayey soils that are slowly permeable at shallow depth, so their rainfall capacity is low (ibid). Finally, significant parts of Mid- and North Devon are covered in clay-rich soils of the Culm Measures, which are naturally slow-draining and waterlogged in winter (ibid). Devon's significantly higher annual and particularly winter rainfall averages in comparison to areas used predominantly for other types of production, eg arable in the South East of England, makes it particularly suitable for pasture cover (ibid). High moisture content or, at worst, waterlogged fields mean that heavy machinery should often not be used to rip, disc, plough etc, between mid-October and end of March (depending on the season) due to high risk of soil compaction (ibid). In addition, livestock farmers must also avoid damaging the soil by limiting grazing during outwintering and housing during substantial portions of the winter to prevent poaching.

Grasslands are thus important across the board, from uplands to lowlands, but people often fail to effectively utilise what they have. Grasslands' dense rooting and earthworm populations provide good soil structure and friable stable topsoils (Smith, 2017), but Lobley and Hopkins (2006, p.2) found that historical management changes to increase productivity in the 1970s

1 Rough grazing is defined as "lower quality grazing land, including heathland, moors, hills and scrub" (Defra 2019b).

("reseeding, increased fertilizer [sic] use, land drainage, increased stocking rates, and early cutting for silage rather than hay") have resulted in environmental damage.

Improperly maintaining grasslands with old / inefficient grass varieties, not rotating grazing, ploughing under permanent pasture to convert to arable etc, are some of the ways soil carbon stocks can be released, compaction can lurk under the surface, in-field biodiversity may be reduced, downstream flooding may result, and not as much dry matter is grown for return on yield.

Agriculturally improved grasslands2, which are the dominant land use in the South West, "are of low botanical interest and usually of low value for other wildlife", so recommended management strategies such as integrating clovers into swards, adapting grazing and mowing management, carving out space for wildlife habitats etc, should be trialled, demonstrated and incentivised through policy solutions and farmer engagement and knowledge transfer (Lobley and Hopkins, 2006, p. 1).

As an example of ongoing research to improve grassland management, the University of Reading Centre for Dairy Research (CEDAR) is leading the DiverseForages Project, which is a five-year study (2016-2020) to compare herbal leys pastures with conventional fertilised ryegrass pastures' resilience to extreme weather, soil structure, ecosystem services, biodiversity improvement and nitrogen fertiliser reductions within ruminant grazing systems. Its findings on the sustainability of such diverse, multifunctional pasture-based approaches should be promoted for widescale uptake, eg through the Environmental Land Management Scheme (ELMS) being developed by Defra post-Brexit (centred around public money for public goods), and further research should contribute to building a solid understanding of optimal pasture and grazing management.

In short, Devon has conditions particularly suitable for growing grass rather than other agricultural products, which humans cannot eat but animals can. But this practice needs to be done in a way that not only avoids risks from poor management but provides environmental benefits. Thus, grass is an essential part of Devon's landscape, but how does it contribute to the farming outputs for the region?

2 "Typically, lowland neutral grasslands that are the result of reseeding with perennial ryegrass and a few other sown species, or as a result of previously unimproved grasslands having been modified by fertilizers, drainage frequent cutting (especially for silage) and/ or intensive grazing leading to botanical composition resembling that of reseeded grassland."

Grasslands' contribution to agriculture

There are 8,162 commercial farm holdings3 in Devon, which are almost a third of all farms in the South West (NFU, 2019). There were 824 dairy holdings in Devon of the 2,426 dairies in the South West in 2016, down from 865 and 2,636 in 2013, respectively (Defra, 2019a). Statistics are not separately available for grass-based versus housed dairy units, but the total area covered by dairies in the South West in 2017 was 320,267 ha (ie 18 percent of the total agricultural area). Additionally, Devon, Plymouth and Torbay County Councils contained 60 percent of the Less Favoured Area (LFA) grazing livestock holdings in the South West (1,380 of 2,331) in 2016, covering 107,862 ha of upland areas, eg Dartmoor and Exmoor (ibid). Lowland grazing livestock operations in Devon totalled 3,114 of the 10,421 holdings in the South West in 2016, covering 149,967 ha or over 30 percent of the total hectares used for lowland grazing in the South West (496,611 ha) (ibid).

These numbers demonstrate the significant role that Devon's grazing livestock and dairies play within the South West's food production system. In addition, the South West exceeds the national average for percentage of farms and farmed area dedicated to both dairy and grazing livestock, showing the importance of the region to national milk and livestock production.

In 2016, grazing livestock farms covered 38 percent of the farmed area with a herd of 187,474 breeding beef and 3,178,000 sheep, constituting 27 percent and 21 percent of all beef and sheep grown in England, respectively (Defra, 2019a). Specifically, Devon's beef cattle numbered 64,657 and dairy cattle numbered 134,947, but significantly, its sheep population was 1,403,847 or 44 percent of all sheep in the South West (ibid).

Financially, the average farm business income for lowland grazing operations in the South West in 2017/18 was £20,600, LFA grazing operations averaged £18,100, and dairy operations averaged £131,300 (Defra, 2018b). For dairy operations, the Basic Payment Scheme payment for 2017/18 averaged £29,200, or 22 percent of total farm business income, whereas for lowland grazing operations BPS payments averaged £16,500 or 80 percent and LFA grazing operations averaged £25,900—which was 143 percent of their total farm business income (ibid). The high percentages for lowland and LFA grazing operations show the overwhelming reliance of many businesses throughout the South West on subsidy support to supplement low market prices for their products. Nevertheless, of the overall agricultural output of the region (£3bn), cattle reared for meat (£399m) and milk sold (£750m) were key components of farming income in the South West (Defra, 2018a).

Grassland management contributes to improvement of farmers' bottom line by reducing costs for purchased feed. Quoting Dr Liz Genever, AHDB Beef and Lamb Senior Scientist, "Grass is the most important, yet often overlooked, resource for livestock production" (AHDB, 2018a). Good utilisation rates through rotational grazing,

3 Defra defines commercial farm holdings as farms "with significant levels of farming activity, that is holdings with any one of the following: more than five hectares of agricultural land, or one hectare of orchards, or 0.5 hectares of vegetables or 0.1 hectares of protected crops, or more than 10 cows, or 50 pigs, or 20 sheep, or 20 goats or 1,000 poultry." (Defra, 2018a).

ie having the right number of animals stocked to eat to the right height of grass at the right time depending on the seasonal conditions, have been demonstrated to exceed 80 percent, thereby maximising the potential of the feed source to be converted into edible protein for human consumption in the form of meat and milk.

Appropriate nutrient management for grass growth is also crucial to avoid losses and make the best use of the resource as possible, eg 52 percent of UK grasslands are losing around 10 percent yield from poor pH management (ibid). Using an AHDB Forage for Knowledge reported average from a Cornish farm as an example of dairy farm cover in the South West, 39 kg DM/ha/day were achieved on average for the 2018 growing season (March-October) (AHDB, 2018b). If roughly applied across the permanent and temporary grasslands in Devon, that average grass growth rate would amount to 15.5 million tonnes of DM annually (with reduced annual growth rate due to the Summer 2018 drought conditions). Commodity prices for purchased feed reflected the shortages experienced from the drought, rising in every major category of concentrate by between 20-30 percent from January to September 2018 (Defra, 2019b). By maximising grass growth and consumption, dairy units utilising grazing were shown to save an estimated 1.3p/litre on purchased feed as far back as 2000, resulting in profitability increases of 0.7p/litre, with later studies showing 1.6-1.8p/litre cost reductions for 6,000 to 9,000 litre herds (AHDB, 2019). This type of strategy to avoid buying in large amounts of expensive feed may become increasingly more important under changing climate conditions.

Case Study - Pasture for Life

The Pasture-Fed Livestock Association (PFLA) is an organisation specifically aiming to promote not only the quality of the products produced on grass but also the wider environmental and animal welfare benefits from pasture-based systems. Through its Pasture for Life brand, consumers may purchase meat and dairy from PFLA certified producers throughout the UK. The organisation envisions itself as the hub for the latest research and implementation of cutting-edge grazing techniques, serving its members who have an interest in sustainable pasture management with learning and support. From a consumer perspective, the PFLA aims to be a highly recognisable quality assurance scheme that is known for delivering high quality, nutritious products from sustainable livestock producers committed to animal welfare. As part of its values, the PFLA aspires to encourage pasture-based systems that are "good for you, good for the planet, good for animals".

Agriculture in the regional economy

Whilst agriculture, forestry and fisheries in the South West employs around 2 percent of the regional workforce and the primary production side contributes nearly 1 percent of the region's economy, it is important to note that agriculture is an industry of self-employment. These figures are both more than double the national average and further processing, manufacturing, tourism and value-added consumption of the region's products collectively make agriculture as a whole vastly more significant than singular statistics reflect (ONS, 2018).

Increasing digitalisation also allows for more diversity in rural employment and for innovative strategies to be explored for increasing the value of economic output from rural businesses (please see Pipers Farm Case Study).

In 2017, 65,217 people were accounted for as agricultural labour force on commercial holdings in the South West (Defra, 2019a), an increase from 63,916 in 2016 and including "farmers, partners, directors, spouses, salaried managers, regular and casual workers" (Defra, 2018a). Specifically, in Devon in 2016, 19,650 people were involved in agricultural labour, of which 7,293 were full-time farmers, partners, directors and spouses and 6,967 were part-time (Defra, 2019a). Regular workers numbered 1,855 full-time and 1,882 part-time, and another 1,242 workers were included on a casual basis. The smallest proportion was salaried managers at 411. The resident population for the county is 787,200, so the proportion involved in agriculture is 2.5 percent (ONS, 2019).

Case Study - Pipers Farm

Pipers Farm is a wholly grass-based sustainable livestock farm based on 50 acres outside of Exeter, Devon. Ruby red beef cattle and Suffolk sheep graze its mixed swards with nitrogen-fixing white and red clover, contributing to the soil sequestration, biodiversity and fertility so there is no need for artificial fertiliser application. Its fields are surrounded by 400-year old hedges that form wildlife corridors and habitats for insects and birds. Utilising new online opportunities for food producers, Pipers Farm has moved from a brick and mortar presence in Exeter to solely online retail, delivered in all sustainable packaging to its patrons. The farm sources from 25 neighbouring farms who ascribe to the same level of ecological, ethical and sustainable standards in order to meet customer demand for its healthy, delicious meat.

The Farm Business Survey for 2017/18 highlights that over two-thirds of farms nationally which meet the minimum size threshold of >25,000€ have some type of diversification action, with over 70 percent of those farms doing something other than letting buildings (Defra, 2018b). There are 5,900 farms of this size processing and/or retailing their farm produce, and an additional 3,500 nationwide providing tourist accommodation and catering (ibid). Overall, the processing and/or retailing diversification contributes an additional output of £160m, which translates into an average supplemental output per farm of £27,100 (ibid). Broken down by income categories (value of output) of those processing/retailing, farms predominantly made between £10,000-50,000 (2,500 of the 5,900 farms doing such activities).

Another significant chunk (1,700 of the 5,900) managed to bring in over £50,000, with the remaining making between £5,000-10,000 down to as little as less than £1,000 (ibid). Specifically, in the South West, there are 11,900 FBS-eligible farms, of which 7,400 engage in diversification activities and 5,400 of those do something other than letting buildings (Defra, 2018c).

Most diversified farms receive at most 50 percent of their farm business income from diversification activities, with 42 percent of SW diversified farms receiving 25 percent or less (ibid). Diversification enterprises bring in £111m of income of the £490m total farm business incomes of diversified farms in the South West; £14m is from processing/retailing farm produce or an average £9,400 per farm and tourist accommodation brings in an additional £4m or £8,400 on average per farm (ibid). The data does not break down whether these diversified farms are dairy, lowland or LFA grazing operations, but further research into the relative distribution of these various diversification enterprises would be useful as the proportional importance of that income will vary drastically based on overall farm business income and dependence on basic farm payment.

Of the various statistics available for the food industry beyond primary production, the Office of National Statistics indicates that the number of people in Devon who worked in distribution, hotels and restaurants in 2017 was 91,500 (ONS, 2019a). Additionally, the local authority profile indicates that there are 36,000 jobs in Accommodation and Food Service Activities in Devon, constituting 13.6 percent of the 265,000 jobs in that industry throughout the wider South West (ONS, 2019b). The agri-food sector can be broken down into agriculture and fishing as well as non-residential catering, food and drink retailing, food and drink wholesaling, and food and drink manufacturing (ONS, 2017). The Food Statistics Pocketbook 2016 shows the national gross value added (GVA) of the agri-food sector, with non-residential catering contributing around £33bn, followed by food and drink retailing at over £29bn and food and drink manufacturing around £28bn. Food and drink wholesaling contributed just above £10bn and agriculture and fishing contributed £9bn. There are informal statistics and findings about Devon's food economy based on the work of Lobley et al. (2012), but further investigation of the intricacies of the local food system would be of value to explore the connection between production throughout Devon's landscape to processing within the region as well as local distribution and direct sales.

As with all industries, it is vital that agriculture gets new people, with new ideas entering the sector (explored further in the New Entrants report from the Devon inquiry (Dooley, 2019a)). However, with agriculture the high cost of land and new business set-up costs relative to the return are significant barriers. One route around this issue for many new entrants is renting small amounts of grassland for a small livestock enterprise and slowly growing this alongside full-time employment elsewhere. This then gives a track record to a landlord and bank down the line when requesting additional operating capital, allowing the business to grow. This sort of start-up model does not function in other agricultural sectors, such as pigs and poultry involving large building infrastructure investments. Therefore, if we want to see new entrants continue to come into the sector, grassland is a vital resource in making gradual entry viable.

Nutrition related to grass-based livestock production

A resource unique to Devon is the North Wyke Farm Platform (see Box, North Wyke Farm Platform). Recent research out of North Wyke by McAuliffe, Takahashi and Lee (2018a) highlights the existing literature around differences in meat quality based upon the feed profiles of livestock, resulting in significant differences in omega-3 and omega-6 ratios (McNeill and Van Elswyk, 2012; Micha et al., 2010; Warren et al., 2008; Simopoulos, 2006). Particularly when finished on grass and clover, fresh red meat has been shown to have an omega-6:omega-3 ratio of 2:1, which is drastically lower than the typical Western diet of 12:1 and even lower than the medically recommended 3:1 to avoid risk of cardiovascular disease (McAuliffe et al., 2018a). Given that red meat is typically low in total fat, dietary risks have therefore been linked to the high proportions of short chain saturated fatty acids (SFA), eg C16:0 (palmitic acid), of which there tend to be lower quantities in grass-fed red meat as well (Micha and Mozaffarian, 2010; Warren et al., 2008). This is a complex area of science that is very much still under investigation, but in attempting to boil it down, it becomes apparent that the message 'red meat is bad for you' is not the entire story. As part of a balanced diet in which more fruits and vegetables must be eaten across the board and smart meat consumption is necessary (Willett et al., 2019), not all red meat is created equal - it depends on the quality of the meat consumed, which is influenced by how it is produced.

Case Study - North Wyke Farm Platform

Housed under Rothamsted Research, a research centre aimed at advancing scientific understanding and technological solutions around agriculture and food, North Wyke tests real-world farming methods to determine which best transfer nutrients from soil to crops, livestock and then into food (Rothamsted 2019). Set in the Devon countryside, four self-contained farms are in operation on the North Wyke site and able to test different management strategies and measure impacts across comparable contexts. This unique resource allows for in-depth assessment of farming practices within the regional context which may then be scaled up across the wider industry, as well as aiming to contribute to healthier diets throughout society and a cleaner natural environment.

Thus, McAuliffe et al. (2018a) have developed a methodology to incorporate the nutritional quality of meat into the lifecycle assessment (LCA) rather than strictly relying on quantity of production or weight of carcass, for example, as the denominator in determining global warming potential (GWP) in the form of kg CO2-eq per unit of food. Under traditional mass-based LCA to determine GWP of different livestock products, extensive beef systems and both lowland and upland sheep compare quite poorly to beef systems feeding concentrates as well as both intensive and free-range chicken and intensive pork. However, once nutritional

quality is factored in (omega-3 content as well as subgroup fatty acids DHA and EPA4), the profiles are flipped with grass-fed beef vastly outstripping concentrate-fed beef, and the fatty acid profiles reflect that extensive beef and lowland and upland sheep have much lower omega-6:omega-3 ratios than chicken produced either intensive or free-range, intensive pork and concentrate-fed beef. These findings challenge the common consumer assumption that white meat is better than red meat across the board from a health standpoint as well as from an emissions standpoint in relation to quality of the outputs, and they challenge the regulatory perspective that all ruminant production should be highly regulated as comparatively more harmful to society than monogastric production (citing Springmann et al., 2017).

These nuances within the debate around livestock production should not reduce the concern for producing the best quality animals with high welfare standards and reducing climate impacts from agriculture (see below) as well as addressing the drastic need for higher fresh fruit and vegetable consumption (Willett et al., 2019). Debates around the highly publicised EAT-Lancet report have ranged from the staunch assertion that 'all meat needs to be cut from all diets everywhere' to 'meat consumption does not need to be reduced at all' to more of a middle ground that 'meat should be eaten that is of higher quality and less frequently'. Overarchingly, it cannot be denied that livestock production releases potent greenhouse gases and the rise of meat consumption around the world linked with higher proportions of middle-class consumers is leading to more Western-style diets and concentrated production units through vertically integrated, buyer-controlled supply chains. However, severe nutrition deficits and healthcare implications from highly processed fat, salt and sugar-based diets are an enormous problem that is spreading to developing economies, eg Southeast Asia (Soon and Tee, 2014), and are often overshadowed by arguments around meat consumption. Further research as to how to raise awareness for consumers, retailers and policy makers in order to induce widescale dietary change towards products with substantially better nutritional quality as well as beneficial comparative climate impacts would be a useful continuation of this work in Devon.

4 Docosahexaenoic acid and eicosapentaenoic acid

Climate-related complexities

Soils are the fundamental basis for agriculture in the UK, but they provide myriad ecosystem service functions beyond that which humans depend on, such as water and nutrient cycling for fresh water and flood management, decomposition and cycling of organic matter, physical platform for construction, cultural and aesthetic value, biodiversity, regulation of air quality and climate, and crucially, carbon sequestration (Adhikari and Hartemink, 2016). Since the industrial revolution, land use change and lack of/change in land cover has negatively impacted the carbon cycle on a global scale, contributing an estimated quarter of cumulative carbon emissions to the atmosphere (Song et al. 2018). As soils are a sink for carbon and their continued disturbance, poor management, degradation and, at worst, desertification releases carbon and other greenhouse gases, scientists worldwide overwhelmingly agree that we need to avoid carbon loss. Protecting peatlands, such as in the uplands, are one major way as globally they "hold between 32 percent and 46 percent of all soil carbon (an estimated 500-700 Gt of approximately 1500 Gt in an area about half the size of Brazil)" (Rumpel et al., 2018, p. 33). Thus, keeping that carbon locked in the soil by not draining, cutting or burning peatlands is a major way to avoid loss (Lobley, 2008).

But also, promoting carbon uptake through management practices proven to enhance soil carbon sequestration is necessary, eg keeping living roots in the ground all year round as with grassland / avoiding bare ground, adding green manures and minimising tillage (ibid; Ostle et al., 2009). This carbon sequestration within a livestock production system would allow for offsetting some of the methane emissions[5] produced by ruminants through enteric fermentation (gases emitted during the digestive process) and manure management (Smith et al., 2014). Agricultural soils, an aggregated category by the Intergovernmental Panel on Climate Change (IPCC) to include manure spread on pastures and applied to soils, synthetic fertilisers and crop residues, are very high in global non-CO2 emissions as well; when combined with enteric fermentation, they represent 70 percent of non-CO2 emissions globally (ibid). Not simply from a climate standpoint, advocates of rewilding, such as Rewilding Britain, argue that large-scale livestock production should be drastically reduced or eliminated and the uplands, for instance, should either be left to nature to determine what the unmanaged landscape will look like or specific flora and fauna should be reintroduced to return it to a previous state. Significant concerns exist, however, around the loss of upland communities, traditions and the current managed landscapes for recreation, archaeology, tourism etc (Colston, 2017; Early, 2018). Additionally, the extent of ecosystem service provisioning from rewilded areas varies depending on what the measured / desired parameters are, eg timber versus pollinators versus aesthetics (zu Ermgassen et al., 2018).

5 Methane has a Global Warming Potential 28 times that of carbon dioxide over a 100-year time horizon according to the IPCC (Greenhouse Gas Potocol, 2016)

Case Study - Emissions from beef cattle systems

North Wyke has produced a novel approach towards life cycle impact assessment (LCA) of different types of grassland management systems. Typically, data on livestock emissions for LCA are based on aggregated inventory analyses, thereby not accounting for heterogeneity in individual animals' performance or across seasons (McAuliffe et al. 2018b). McAuliffe et al. (2018b) were able to incorporate these differences, basing the LCA on post-weaning liveweight gain (LWG) for animal performance and high spatial and temporal data from the North Wyke Farm Platform. Following weaning, cattle were allocated to and grazed exclusively on three farmlets under different pasture management systems: 1) permanent pasture (PP) ("no field has been reseeded for at least 20 years"), 2) white clover/high sugar perennial ryegrass mix (WC) (aiming for 30 percent ground cover by white clover), and 3) high sugar perennial ryegrass (HS) (with the latest improved grass varieties).

Unsurprisingly, the study confirmed that rumen-related methane emissions were the highest source of GHG emissions in all systems, irrespective of pasture management and performance. Additionally, in terms of lowest average emission intensity, the WC system performed the best at 16.0 kg CO2-eq/kg LWG compared to 18.5 kg CO2-eq/kg LWG for the PP system and 20.2 kg CO2-eq/kg LWG for the HS system because of its lower requirements for inorganic N fertiliser. However, animals on the PP system showed a larger average daily gain rate than the other two, which caused it to be the most favourable farmlet in direct livestock emissions, in part due to WC's low nutrient values in crude protein and the HS' low digestible energy.

Animal performance within each system differed drastically, with the best and worst performing animals varying by 33 percent (PP), 52 percent (WC) and 54 percent (HS) in emissions intensity. Steers also performed better than heifers on the WC and HS systems. Notably, whilst the HS heifers finished quicker due to lower target weight and ease in meeting carcass specifications, the relative emissions savings were not large enough to offset the benefits from higher target growth of the steers.

PP systems therefore may allow for less stringency in animal selection and offer a comparative advantage as a stable system, presenting strong evidence for their maintenance and benefits within South West food production.

Additionally, strategies for WC and HS systems such as spatial separation, overseeding and precision agriculture may need to be explored to reduce sward spatial variability. Ultimately, land use change to other types of production were not included in the LCA because "grasslands in the southwest of England are typically located on hilly land with soils that become supersaturated…[therefore] unsuitable for arable crop production". Thus, promoting grazing systems where grass is the land's best output makes sense from a strategic land use standpoint.

In an area fraught with conflicting opinions about how individuals should manage their land, it appears that the balanced approach would be to improve management of what will remain grasslands, eg significant research is emerging around long-term grassland management in the UK as carbon sinks regarding below-ground nitrogen and carbon pools, liming and land use conversion (Carolan and Fornara, 2016; 2017; Heyburn et al., 2017; Egan et al., 2018; Eze et al., 2018).

Also, less productive arable land should potentially be prioritised for conversion to permanent grasslands in order to avoid negative impacts (eg erosion, compaction, over-fertilisation etc) as well as increase the soil carbon profile (Gosling et al., 2017). Payment for public goods should be provided as these objectives will require additional, different management to achieve higher collective benefits (though not necessarily incurring loss of productivity), and those landowners who would like to rewild their lands may do so for similar public goods payments as well as the additional income from tourism and possibly public-private partnerships with water companies for avoided costs from diffuse pollution and/or natural flood risk management (Wheeler et al., 2016).

In the UK, soil data is scarce but Defra has estimated, roughly, that cost of soil degradation in England and Wales in 2011 totalled around £1.2bn per annum, of which 80 percent was attributed to compaction and loss of soil organic matter (NCC, 2019). Moreover, based on a social cost of carbon of £173 per tonne of CO2, the loss of soil carbon to the UK may be as high as £3.2bn per year (ibid).

Estimations for rates of carbon sequestration in UK agricultural land vary, largely due to factors such as the non-linear and variable rates of sequestration between soil types and conditions, lack of permanence and vulnerability to disturbance, and saturation levels (McAuliffe et al., 2018b; Soussana et al., 2009; Beauchemin et al., 2011). Generally, however, UK agricultural land and soils' mitigation potential is estimated to range from 1-2 Mt CO2-equivalent per year-1 (Fitton et al., 2011) to 1.6-10.2 Mt CO2-eq. yr-1 (MacLeod et al. 2010) to 6.5 Mt CO2-eq. yr-1 (Moran et al., 2011). The maximum feasible potential estimated is ca. 11 Mt CO2-eq. yr-1 (Smith et al., 2010), but fitting with the risk of land use conversion or ploughing existing grasslands to grow other crops, potentially 14 CO2-eq. yr-1 may be released if 20 percent of UK grasslands were converted to cropland (Smith, 2012).

In addition to soil organic carbon sequestration increases from integrating mixed cover crops (legumes and non-legumes) onto arable fields (Abdalla et al., 2019), Soussana et al. (2009) found that grasslands that are not intensively managed cut sites have the potential to increase soil carbon stocks to partly mitigate the GHG balance of ruminant production systems, including recommendations to moderately intensify nutrient-poor permanent grasslands, increase grass leys duration, and/or convert grass leys to grass-legume mixtures or permanent grasslands. Therefore, maintaining and enhancing management of UK grasslands presents a viable option for contributing to the reduction in overall GHG emissions from agriculture.

Recommendations

- Further research and policy development work should be undertaken to support developments in agricultural practice which improve sustainable grassland yield and utilisation. Specific focuses of such work should include providing guidelines to farmers on sequestering carbon and simple soil organic matter; lifting carbon sequestration from the 'too difficult box' in research terms; measurement tools to enable policy nudges so farmers can produce environmental public goods funded by public goods agenda.
- In order to overcome confusion and misperceptions about grassland livestock farming, the differential dietary, economic, social environmental and climatic benefits of these farming systems and their products should be promoted by the industry.
- Researchers and policy makers should take a holistic approach to understanding grasslands' ability to deliver public goods (as defined by government requirements - impacts on climate change, lack of emissions, carbon sequestration etc). This will involve bringing together strands of work which are currently separate (such as investigations into less input-reliant agriculture using permanent pasture, diverse swards, use of legumes, and sustainable systems of management).
- Industry should be proactive in its engagement with government, policy makers, the research community and other key stakeholders such as AHDB. This is needed across key issues including: increasing carbon storage; employment; better grass quality and more sustainable production. This approach is needed internationally, nationally and locally in Devon and the South West.
- Research should be co-produced with the farming community where possible, to ensure the sector buys in to and implements recommendations.
- Funding from government and other stakeholders should be made available for work which translates research findings into activities which create impact and disperse knowledge.
- Government, the research community and the agricultural sector more widely should recognise and acknowledge farmers as key partners in solving challenges within the sector. All research, policy and engagement should reflect and promote this approach.
- Development of the Agriculture Bill and future funding for the sector should establish grasslands as a key asset to be valued.
- Stakeholders in industry and education should support the next generation of farmers to recognise the value of a career in the grasslands sector. This includes providing support and advice, for instance via AHDB and ELMS, to help them to become part of progressive change and innovation within the sector.

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