UCR

# Sustainable Agriculture: Embedding environmental practices on conventional livestock farms

**The Farmer's Club Charitable Trust**

**Agricultural Educators Award**

Tom Furness PGCert, BSc (Hons)

University Centre Reaseheath

The Farmers Club Charitable Trust

University Centre Reaseheath

# Contents

# Table of Figures



# Table of Tables

## Acknowledgements

I would like to express my sincerest gratitude to The Farmers Club Charitable Trust for the funding provided through the Agricultural Educators Award which has supported an extensive programme of continuous professional development related to sustainable agriculture. The experience has been both enjoyable and rewarding, and has been timely given the development of University Centre Reaseheath's new Sustainable Agriculture degrees.

# Introduction

The global livestock sector accounts for approximately 14.5% of total anthropogenic greenhouse gas emissions (GHG) (Grossi et al., 2019). Of these emissions, 39% are methane derived from enteric fermentation in ruminant livestock. Feed production, including the application of chemical fertilisers and organic manures account for a total of 45% of livestock emissions (Gerber et al., 2013). In addition to GHG emissions, reliance on synthetic fertilisers has compromised soil and water quality, resulting in nutrient surpluses in soils, currently 51.1kg N per ha in Europe (European Environment Agency, 2018), and eutrophication in water courses through nutrient leaching which is thought to account for 78% of global ocean and freshwater pollution through eutrophication (FAO, 2018).

Biodiversity in UK grasslands has also decreased as Perennial Ryegrass (*Lolium perenne*) and Italian Ryegrass (*Lolium miltiforum*) have become the most commonly utilised grass species due to their high dry matter (DM) yield and digestibility (Riviero, et al., 2019). As a result, poor species diversity makes the sector vulnerable to the effects of drought and global warming (Westermeier et al., 2016).

Of the many mitigation strategies available to reduce the environmental impact of agriculture, more specifically livestock agriculture, the plethora of low input farming systems such as Organic, Regenerative and Conservation agricultures are not widely distributed or favoured. Only 2.9% of the UK's agricultural land, for example, is under certified organic management (Defra, 2022), and although the UK has undoubtably increased area under regenerative management, the lack of "certification" makes the quantification of this challenging.

*Table 1: Principles of organic and regenerative agriculture*

| **Organic Agriculture (IFOAM, 2023)** | **Regenerative Agriculture (Savills, 2023)** |
|---|---|
| 1. Principle of Health: sustain and enhance the health of soil, plant, animal, human and planet<br>2. Principle of Ecology: based on living ecological systems and cycles, work with, emulate and sustain them<br>3. Principle of Fairness: build relationships that ensure fairness with regard to the common environment and life opportunities<br>4. Principle of Care: precautionary approach to protect health and wellbeing of environment and future generations | 1. Minimise soil disturbance<br>2. Maximise species diversity<br>3. Keep the soil covered<br>4. Maintain living roots year-round<br>5. Integrate livestock |

Organic Livestock Modelling (SOL-m) by Shader et al. (2013) shows that whilst the full conversion of livestock to organic production would decrease nutrient inputs, soil nutrient surpluses and overall global warming potential, the quantity of land required to maintain production would increase significantly, causing overexploitation of grasslands and further exacerbate deforestation pressures. Sector-wide modelling in England and Wales conducted by Smith et al. (2018) yielded similarly worrying results, with only 64% of food output as metabolizable energy achieved in organic systems compared to conventional, likely to result in significant increases in food imports. Loss of production would be greatest in cereal, oilseed and monogastric (namely pig and poultry) sectors, with only vegetable producers achieving comparable yields in organic and conventional modelling.

Since the global pursuance of any one strategy to sufficient levels was said by Shader et al. (2018) to be “expensive and unrealistic”, the purpose of this CPD programme was to investigate the wide range of sustainable agricultural practices, particularly those aligned to organic and low input production, which could be implemented on conventional livestock operations without the need for radical conversion or change.

# My TFFCT Agricultural Educators Award

## CPD Aims

The aims of the project were to:

1. Identify sustainable agricultural practices aligned with the underlying principles associated with certified organic, regenerative and similar low-input production systems
2. Evaluate the ecosystems services delivered by these agricultural practices
3. Determine the suitability of these practises for adoption by conventional farms
4. Collect case studies of good practice to inform and enhance teaching practice

## CPD Overview

Table 2 outlines the range of activities undertaken over a period of two years to complete the Agricultural Educators Award. The broad range of activities included a number of online and in-person conferences and farm-visits as well as formal study via distance learning a Grassland Management module at the Institute of Biological, Environmental and Rural Sciences (IBERS), Aberystwyth University.

*Table 2: Overview of CPD undertaken as part of the Agricultural Educators Award*

| Date | Event/Training | Mode |
|---|---|---|
| April 2021 | TEDx Sustainable Food Trust - | Virtual |
| Aug 2021 | Cornwall Beaver Trust | In-Person |
| Sept 2021 | IFOAM Organic Food Conference | Virtual |
| Sept – Dec 2021 | IBERS Grassland Management Module | Virtual |
| April 2022 | AHDB Staffordshire Dairy Roadshow | In-Person |
| May 2022 | Cultivate- Rural Growth Summit | In-Person |
| July 2022 | AHDB Low Ballees Farm, Scotland | In-Person |
| August 2022 | 22nd World Congress on Soil Science | In-Person |
| August 2022 | AHDB Health Soils | In-Person |
| October 2022 | IAgrM National Farm Management Conference | In-Person |
| November 2022 | A & M Webster, Lancashire | In-Person |
| March 2023 | AHDB Research Roadshow – Metcalfe Farms | In-Person |
| April 2023 | Landex Agricultural Lecturer's Event - AEA Dissemination | In-Person |

## 22nd World Congress on Soil Science

Although I attended the 22nd World Congress of Soil Science mid-way through my project, I thought its background and context provided a fitting introduction to my project and report. Soil was, undoubtedly, the single biggest reoccurring theme featuring in the majority of my CPD activities.

I arrived in Glasgow just in the nick of time to attend the opening ceremony of the congress, which was opened by Dr Bruce Lascelles, president of the British Society of Soil Science (BSSS). After speeches from key stakeholders including His Royal Highness the Duke of Gloucester, we were bag-piped over the River Clyde to the Glasgow Science Centre for a drink's reception.


*Figure 1: Scottish Event Campus and opening ceremony*

Professor Ismahane Elouafi, Chief Scientist of the Food and Agriculture Organisation (FAO) of the United Nations (UN), opened the first conference session the following day and laid bare issues surrounding soil and the need for sustainable food-systems in order to achieve the 17 UN Sustainable Development Goals (SDGs), which have become the blueprint for international policy development since the launch of the 2030 Agenda for Sustainable Development in 2015.

### Sustainable Development Goals

The most obvious SDG linked to soil science is "*SDG 15 – Life on Land*", as soil acts as a substrate for most eco-systems services; eco-systems services being the services which ecosystems provide to humans. Unfortunately, 33% of land globally has suffered some degree of soil degradation such as soil erosion and organic matter depletion, and is estimated to cost the world $8billion annually (FAO, 2015). Alarmingly, FAO modelling predicts that this will only worsen without preventative action, with over 90% of land expected to be affected by 2050. Organic matter depletion, in particular, provides an issue for maximising soil carbon capture in light of climate change ("*SDG1 – Climate Action*"), with soil carbon stocks reduced in many of the world's main agroecosystems such as

croplands, grasslands and peatlands. As well as a direct impact on soil and plant biodiversity, its effect on nutrient instability within the soils also results in poor water quality through diffuse water pollution, primarily from nitrates and phosphates, negatively impacting the globe's capabilities of achieving "*SDG6 – Clean Water & Sanitation*" and "*SDG14 – Life below water*". Collectively, these environmental impacts impede global food security and impact on food quality ("*SDG2 – Zero Hunger*" by 2030).

The implications on society are often the less obvious connections to make between depleted soil health and sustainable development although are sometimes easier to recognise in the developing world. Low soil-mineral content, for example, contributes significantly to the deficiencies of vitamin A, iron and zinc in the diets of children and pregnant women where the availability of supplementation is limited. This subsequently limits the growth and health of children and limits "*SDG10 – Reduced Inequalities*" and "*SDG3 – Good Health and Wellbeing*". Similarly, reduced agricultural productivity reduces economic growth ("*SDG8 – Decent Work and Economic Growth*") which in turn will prevent access to essential health care and education where agriculture is the primary source of income ("*SDG4 – Quality Education*"). There are, of course, more sustainable development goals, however it is clear from just these few that soil plays a vital role in our existence.

## Opportunity

Despite strong messaging around the environmental emergency, there was a resounding sense of hope and opportunity from all speakers at the sessions I attended. Professor Peter Gregory of the University of Reading, for example, talked us through the co-evolution of soil and plants some 850million years ago, when the first photosynthesising bacteria and eukaryotes began to capture atmospheric carbon, resulting in the formation of soil and evolution of plant species. If nothing else, a timely reminder that microorganisms that once developed our soils could regenerate our soils once again given the appropriate management and use of our ecosystems.

On Tuesday I attended the first policy programme in the history of the World Congress of Soil Science, which was a particular highlight of the congress. Policy development is a delicate subject, and one incredibly hard to get most people (particularly students) enthused about, despite it having a profound effect on each and every one of us. Personally, I find the balancing of economic, social and environmental development a source of such highly contentious debate and discussion.

Ronald Vergas, Secretary of the UN's Global Soil Partnership highlighted the place of soil in a global landscape of policy development and conveyed very eloquently the need for change at a governmental level to help broaden the world's approach to combatting soil degradation. It was

pointed out that unlike water and air, soil has no specific recognition as an SDG despite providing that essential interface between air and water. The ability of soil to filtrate water and improve water quality is one just ecosystem service provided by soil which is relied upon by us all, whilst the role of soil in carbon capture provides a perfect opportunity to improve air quality. A factor influencing this was said to be the vast range of soil types globally and the lack of consistently measurable soil parameters in which UN member nations can monitor and benchmark whereas water and air quality have been much easier and consistent to analyse.

To help reduce variances in soil analyses, The Global Soil Laboratory Network has been working to harmonise the methods in which labs collect and analyse soil to improve comparability of data globally, as well as working to increase capacity of soil laboratories.

An organisation at the forefront of improving the relationship between science and food producers is the Soil Health Institute in the United States of America. Chief Scientific Officer Professor Christine Morgan discussed their recent advances in digital technology through the “North American Project to Evaluate Soil Health Measurements” which aims to improve both agricultural productivity and environmental sustainability in a way which puts the farmers and their advisors at the heart of decision making.

Two ongoing projects are the development of digital apps to estimate aggregate stability and model the impact of a variety of management options, such as tillage, cover-cropping and crop rotations. In short, aggregate stability is a measure of the ability of soil particles to bind and resist forces such as water and wind. Its use would allow farmers to take a data informed approach to soil erosion mitigation whilst the availability of an economic predictive tool would empower farmers to balance environmental sustainability with farm productivity and subsequent economic margin, which can often me a limiting factor for implementing change.

On the Wednesday of the congress I attended the regenerative agriculture session. Of the hundreds of speakers programmed across the week, I had strategically selected those that I thought would cover the five principles of regenerative agriculture. Despite this, I was surprised how little there was in the way of livestock integration and the role livestock play in nutrient cycling, building soil organic matter etc. Given the nature of my project, this was disappointing but does highlight an area of research which further needs exploring. That said, it did seem that livestock was the one sector of agriculture which the soil and environmental science community dared not to mention in any positive light, as if no good could ever come of our environmental Voldemort.

## Networking

After three long days of congress proceedings, it would have been remiss of me not to attend the congress gala dinner held at the fabulous Kelvingrove Art Gallery and Museum. The museum was opened in 1901 as the “Palace of Fine Arts” and I was pleased in one regard that I had gone all out on a dinner jacket and UCR yellow bowtie, befitting for such a venue, however I felt immediately overdressed when I arrived to find only a hand-full of delegates in bow tie.

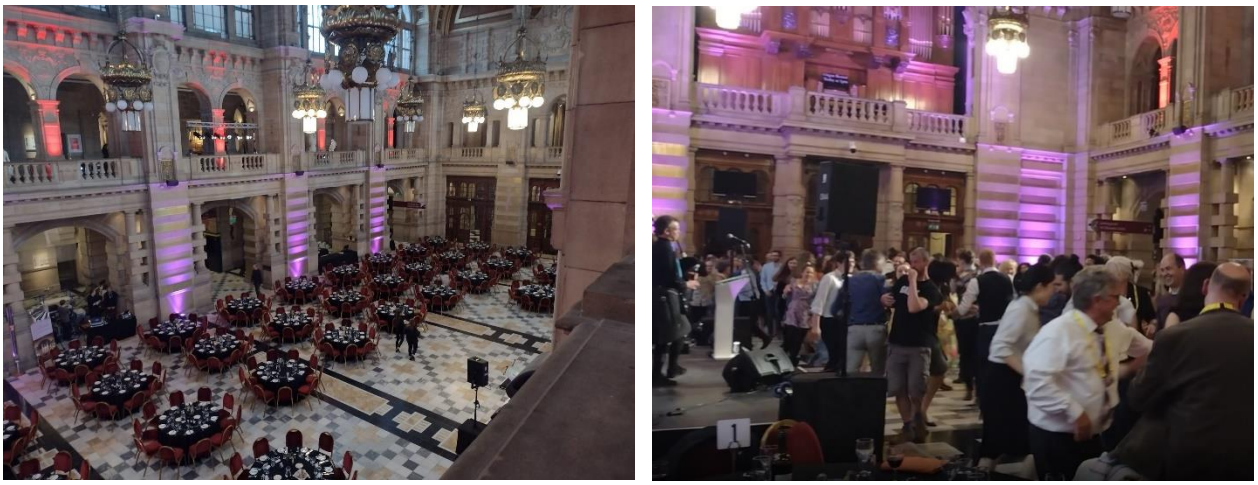

*Figure 2: Congress diner at the Kelvingrove Museum*

The food, wine and ceilidh band were excellent however what was exceptional was the company. Earlier in my project I had attempted to dip my hooves into the world of online conferencing however I quickly recognised that these virtual platforms could never replace the opportunities and experiences of in-person events. The World Congress of Soil Science epitomises this and was a truly diverse networking opportunity. At dinner I had the company of two researchers from Agroscope – Switzerland’s centre for agricultural research – to my left, and to my right I had researchers from Hungary and Germany, all eager to share their stories. One can never emphasise to students enough the importance of finding opportunities to meet people, ask them questions, hear their stories and share their ideas with. Overall an experience to remember.

## Woodland Valley Farm, Cornwall

The first of my physical adventures was a weekend in Cornwall to visit Woodland Valley Farm with colleagues from our wildlife and ecology team as part of a CPD weekend.

The 60ha (170acre) farm, produces Pasture for Life Association (PFLA) and Soil Association certified organic beef for direct to consumer sales. The farm prides itself on the wide range of habitats it hosts including over 10ha of woodland, as well as numerous streams and ponds. Farming practices include:

1. Rewilding Beavers
2. Diverse Swards
3. Agroforestry
4. Mob/Rotational Grazing
5. Minimum Tillage & Direct Drilling

Chris Jones and his family have a wealth of knowledge and experience in farming sustainably. Their achievements over the years include the transformation of their mixed farming operation producing 350t carbon dioxide equivalent ($CO_2$-eq) to an entirely grassland-based livestock business achieving net sequestration of approximately 350t $CO_2$-eq through adoption of environmental practices such as herbal leys, mob grazing and agroforestry.

### Rewilding

It is ironic that in a project aimed at avoiding radical change my first farm visit was in fact a rewilding project. In 2017, the farm embarked on a project to reintroduce beavers in approximately 2ha of plantation woodland along Nankilly water with the intention reducing the water-flow of streams, create wetland habitat and improve biodiversity.

I had read of such projects in the USA where expanses of land have been transformed from near desolation into thriving ecosystems through use of these “landscape engineers” (Kozlowski et al., 2016). Maggie Creek, pictured in Figure 3, is a perfect example in America of where adaptations and reforms to agricultural practices combined with the release of beavers have resulted in positive regeneration of whole landscapes.

*Figure 3: Maggie Creek, Navada, USA in 1980 (left) compared to 2011 (right). The impact of livestock reduction and beaver reintroduction on landscape restoration. (Photo credit: Bureau of Land Management, Elko District.) Cited by (Gray, 2020).*

That said, it is well reported that farmer perceptions of beaver reintroduction are poor, particularly where their presence conflicts directly with farming enterprises (Auster et al., 2019), therefore it was useful to garner Chris' thoughts from a farmer's perspective.

A recently published report, titled "*Report on the Welfare of Beavers in Scotland*", commissioned by the Scottish Government (2022) is an interesting read and cites research by authors such as Hamilton & Morgan (2015) who report economic losses in the Tayside catchment in Scotland. Whilst quantifiable costs were incurred by only 12% of landowners, the costs ranged substantially from £300 to £10,000 per year, estimating total costs to the catchment of up to £179,000. Since then, the National Farmers Union of Scotland reported in 2021 of one particular vegetable grower losing an estimated £25,000 of crop due to beaver-induced flooding. Despite this, Scotland has recognised beavers as a protected native species since May 2019. Although I did not visit Tayside as part of this project, the region now serves as a perfect case study to use for the purposes of monitoring ongoing issues and impacts at a landscape-level , since its beaver population has now exceeded a thousand in number.

This human-beaver conflict was a topic of conversation during the visit and whilst Chris is, of course, in support of beaver reintroduction, he was also in support of appropriate controls such as those he had seen in Bavaria where populations had reached tens of thousands. In particular, he thought that there was much less conflict in areas where a reduction in water flow in streams and rivers was desirable. Conversely, he gave examples of situations in lowland areas were beavers became especially problematic due to the nature of prime arable operations and the need for efficient water drainage and flow. In the case of the Cornwall Beaver Project, the ecosystems services reach distances much further than the farm with a 23% reduction in peak flow during the wet season reducing the likeliness of flooding downstream (Puttock et al., 2020).

I was truly impressed by the impact the beavers are having in this woodland which is now a remarkable wetland habitat of dams, ponds and shallow streams; well worth the endless Cornish traffic jams for a visit.

*Figure 4: Beavers in their enclosure on Woodland Valley Farm*

## IBERS: Grassland Production

With a wealth of research indicating that soils and grasslands can contribute to the reversal of climate change, I took the opportunity to study a postgraduate-level module via distance learning, titled "Grassland Production", at the Institute of Biological, Environmental and Rural Sciences (IBERS) at Aberystwyth University.

Multispecies swards, often referred to as herbal lays and diverse swards, were a key focus for me in this module and my conclusion is that they are probably one of the greatest opportunities for improving the sustainability of livestock farming. I mentioned previously that they were a feature at Woodland Valley Farm, but what are they?

### Diverse Swards

There is no standard formula for the formation of a diverse sward, however two or three leguminous species, such as white clover (*Trifolium repens*), lucerne (*Medicago sativa*) and sainfoin (*Onobrychis viviifolia*) are typically selected along with several grass and forb species to formulate a mix suitable for individual farm soil-type, forage requirement and management system (Zaralis et al., 2016). Whilst many people think that this is a new concept, these swards are not too dissimilar to swards we would have once seen prior to the industry's drive for grassland improvement and intensification which has seen a significant increase in perennial and Italian ryegrass swards. In essence, ryegrass has become the staple of grassland production not only in the UK, but in countries around the world, which has undoubtedly caused a reduction in grassland biodiversity globally.

The effects of multi-species swards on dry matter (DM) yield per hectare can be variable and will likely present a psychological barrier to farmers when considering this particular cropping system (Price *et al.,* 2017), especially as most are used to the relative consistency and predictability of typical perennial ryegrass swards. Cardinale et al. (2007) and Finn et al. (2013) did, however, find that diverse swards yielded 1.7 and 1.3 times more biomass, respectively, compared to swards which were monoculture in composition. There are several factors which impact on the level of yield elevation in multi-species swards, including species selection, species number and subsequent inclusion rate. For example, inclusion of plantain (*Plantago lanceolate L.*) at a rate of 20% increased dry matter yields by 10% (P=0.04) compared to grass-clover mixtures whilst 60% inclusion gained only 14% (Cong et al., 2017).

Inclusion of legumes at 30-50% of sward composition is thought to yield greatest total benefits (Luscher *et al.,* 2009), although optimum inclusion rates for forbes are less defined and inclusion is not always reflected in subsequent dairy cow yields (McCarthy et al., 2020). An observation both on-

farm and in the literature was that composition of the seed mixture will not define the composition of the sward at any one point in the year or indeed the life-time of the sward. Some forbes, for example, suffer from poor grazing persistency and frost tolerance with many failing to persist beyond 3 years (Jaramillio et al, 2021), whilst some species will take longer to grow in the spring and others stop growing much sooner in the summer and autumn.

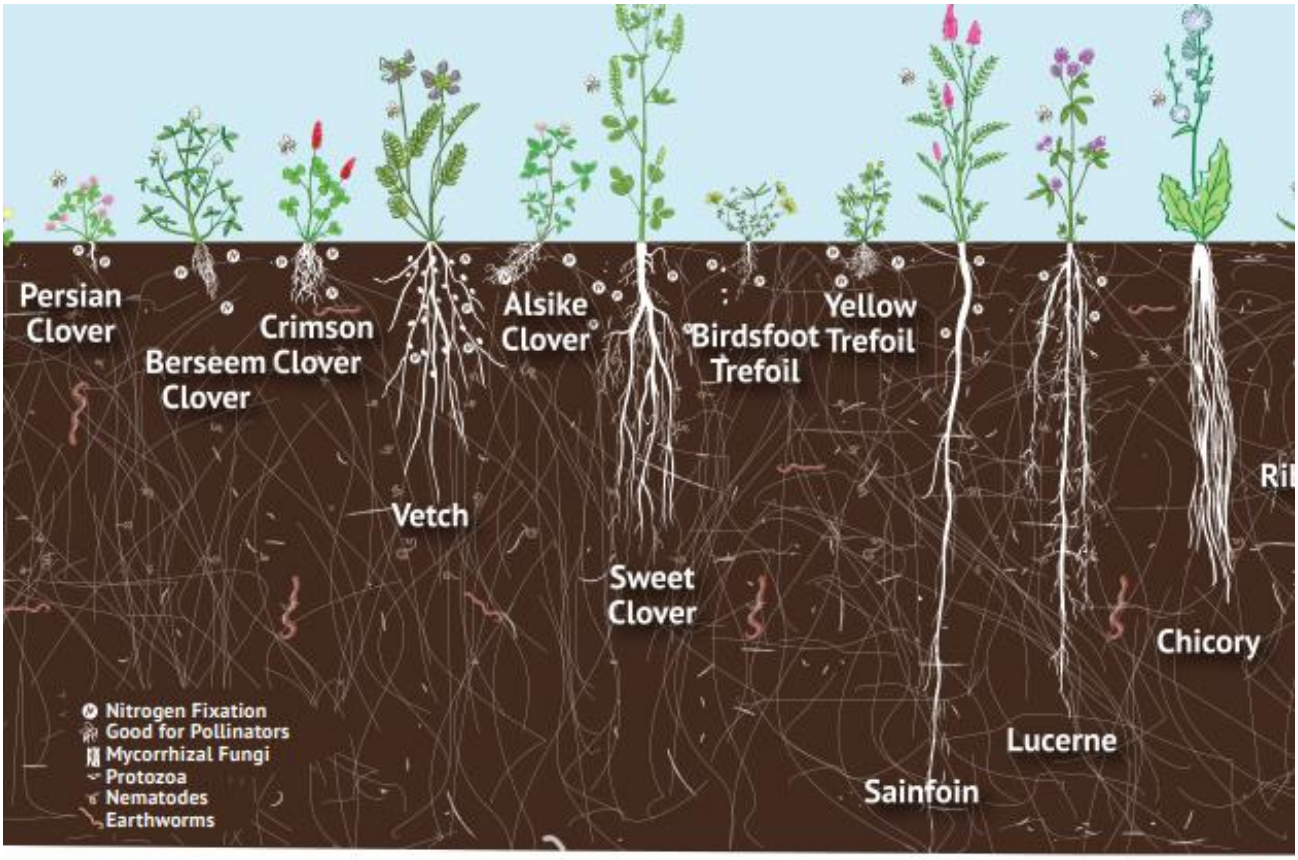


*Figure 5: Diagram of various crop rooting depths (Cotswold Seeds, 2021)*

A major contributing factor to this is the rooting depth of the crop, which can vary significantly as shown in Figure 5. Improved soil structure and aeration provide increased root respiration and subsequent cation-exchange capacity, which are all benefits provided by deep rooting plants. In turn, this increases access to minerals and water deep in the sub-soil, resulting in greater drought tolerance (Grange et al., 2021) and better distribution of biomass accumulation throughout the growing season (Sleugh et al., 2000). Grange et al. (2021) found that diverse swards in drought conditions can yield comparable herbage mas to simple, high-input swards in non-drought conditions.

As well as biomass supply, the quality of nutrients may also be improved, with the rate of decline for certain legumes, such as white clover, much slower towards the end of the growing season than for

grasses (Luscher et al., 2014). In research by Peyraud et al. (2009), diverse sward digestibility decreased by 20g $kg^{-1}$ DM per week, resulting in a decrease in dry matter intake, however this decrease was only half that of regular grass swards. Overall, research suggests that prolonged and improved nutrient supply to grazing animals can be achieved through sward diversity (Pemberton et al., 2015), ultimately resulting in greater forage availability in a changing climate (Grace et al., 2018).

Nitrogen fixation from leguminous crops provide a source of natural nitrogen thus building soil fertility and reducing synthetic input costs (Zaralis et al., 2016; Finn et al., 2013). Common leguminous crops such as white clover can produce as much as 545kg N per hectare, whilst other less common species such as sainfoin can fix up to 480kg per hectare (Carlsson & Huss-Danell, 2003). As well as having a positive impact on total sward yield, an increase in crude protein concentration per kg of DM helps to create a circular economy in terms of protein supply which should help to reduce the requirement to purchase imported protein feeds (Peyraud et al., 2009).

Carbon sequestration and soil organic matter potential of grasslands may also be improved with the use of species rich swards due to greater root biomass and above-ground herbage mass (Whenua, 2020). It is estimated that a seven-species sward compared to a ryegrass/clover sward, can increase soil carbon inputs by up to 1.2tC $ha^{-1}$ (McNally et al., 2015). Without doubt, the inclusion of diverse swards at Woodland Valley Farm has contributed significantly to the decline in their carbon footprint.

## AHDB Events

The horticultural and potato sectors would likely disagree, however in my opinio n the Agriculture and Horticulture Development Board (AHDB) are an essential facilitator of collaboration and knowledge exchange in Agriculture. Their strategic farms programme, in particular, has showcased excellent working examples of positive change with a wide range of focusses, allowing research and industry to integrate for the benefit of progression. Their programme of events expanded rapidly as the UK emerged from the depths of the pandemic and I took advantage of these events on a number of occasions during this project including a Soil Health Day, two Dairy Research Roadshows and a carbon net zero strategic dairy farm launch.

## AHDB: Low Ballees Farm, Ayrshire

Low Ballees Farm, owned by David Campbell and family, is Scotland's newest AHDB strategic dairy farm, and the first of two to be launched in the UK with a specific focus on achieving carbon net-zero.

The farm extends to 125ha, including over 13 ha of woodland and 1.3 ha of deep peat, and is home to a herd of 130 Holstein/Friesian dairy cows which are housed and calved all-year-round (AYR). The herd are milked robotically and are bred to sexed semen for herd replacements and beef sires to produce beef calves for sale.

Home grown forages include grass silage, whole-crop cereals and zero-grazed grass whilst 20ha of land supports the production of cereal crops allowing Low Ballees to achieve between 80-100% self-sufficiency in barley grain, whole-crop wheat and straw.

*Table 3: Key Performance Indicators (KPIs) of Low Ballees Farm against top 25% AHDB benchmark (2018/19)*

| KPI | Low Ballees | Top 25% Benchmark |
|---|---|---|
| Average Milk Yield (l) | 11,000 | 8,749 |
| Butterfat % | 4.1 | 4.04 |
| Protein % | 3.3 | 3.32 |
| Age at First Calving (months) | 24 | 26.5 |

*Figure 6: Low Ballees Dairy Farm*

## Water & Slurry Management

A key development for Low Ballees Farm in relation to slurry management was the construction of a 4500 $m^3$ lagoon in 2018 which was constructed away from the farmstead and used for long-term storage with the original 900$m^3$ tower lagoon located at the farmstead now providing only short-term storage. Collectively, these facilities provide between sixteen and eighteen months of storage which is well above the minimum requirement of six months and ensures application of organic manures in optimum conditions for optimum nutrient utilisation, thus reducing likeliness of nutrient leaching and the necessity for inorganic fertilisers and their associated costs and risks.

*"The lagoon was installed with a 10-year outlook. The reality of payback is less than five years, given the increase cost of inorganic fertiliser" - Tom Campbell (AHDB, 2022)*

Yard developments have been pivotal in significantly reducing volume of slurry, with clean and dirty water managed entirely separately. Whilst clean water, such as roof water, is fed directly to the nearby water course, dirty water from areas such as concrete yards are now channelled into a series of ponds which provide a natural source of sediment filtration allowing water to be returned to the environment. These ponds have developed into a small wetland area, providing habitat for birds and waterfowl.

*Figure 7: Slurry Lagoon, Low Ballees Farm*

## Carbon Auditing

Working with farm business consultants SAC Consulting, Low Ballees Farm have been conducting farm carbon audits over the past few years using the "AgRE Calc" calculator and are performing well below UK average per kg of fat- and-protein- corrected milk. Efficiencies in production have had significant impact on emissions intensity per litre of production, whilst 13 ha of woodland and 1.3 ha of deep peat provides good carbon sequestration to help offset their carbon production.

*Table 4: Carbon footprint of Low Ballees Farm 2021-2022 (SAC Consulting, cited by Farmers Weekly, 2022)*

| | Year Ending June 2021 | Year Ending June 2022 | % Change | UK Average (AHDB) |
|---|---|---|---|---|
| **Farm carbon footprint*** (carbon dioxide equivalent ($CO^2e$)/kg output) | 1.39 | 0.81 | -41.69 | - |
| **Dairy carbon footprint** ($CO^2e$/kg fat- and protein-corrected milk) | 1.21 | 0.95 | -21.4 | 1.25 |
| ** Including carbon capture from farmland hedges.* | | | | |

On the day, there was a number of questions asked regarding the calculator used by SAC, and much debate was had on the standardisation of the many (approximately 70) available in the UK. ClimateXChange, Scotland's centre of expertise on climate change, conducted an analysis of farm-based carbon audits on beef farms in 2019 and found that there was great variability in the features and parameters of the calculators, despite complying with international standards (IPPC, PAC2050). The study selected three which provided the greatest level of input and comparability, yet still found variability in emissions calculated, as seen in Table 5 (Wiltshire et al., 2019). It was clear from delegates that if the industry is to be convinced that carbon auditing is a useful exercise, then it would need to be assured that the process was fair and consistent.

*Table 5: Results from comparison of different carbon footprint calculators (Wiltshire* et al., *2019)*

| | AgRE Calc | Cool Farm Tool | Solagro CC |
|---|---|---|---|
| **GHG Emissions** ($kgCO_2e$/kg liveweight) | 31.6 | 7 | 22.34 |
| **Total Farm Emissions** (kg $CO_2e$) | 625,712 | 581,830 | 665,380 |
| **Emissions per ha** (kg $CO_2e$) | 6159 | 5704 | 6460 |

Funding provided by the Scottish Government through the Farm Advisory Service has helped uptake of carbon auditing in Scotland, with their funding scheme exceeding capacity in 2022. The dominance of SAC Consulting in farm business consultancy in Scotland has positioned Scotland well for the roll out of sector-wide farm carbon auditing activity, and should ensure the standardisation of carbon audits in Scotland. The rest of the UK could learn a lot from Scotland in this regard and implementation of sector-wide carbon auditing would be beneficial for setting benchmarks and supporting farming businesses move in a sustainable direction.

## Cultivate Conference – Rural Growth Summit

At this point in my project, I had explored a number of sustainable practices, however I had not considered the sustainable management of the rural business outside of the field. As one of the first conferences scheduled in the aftermath of the pandemic, I took the opportunity to attend the "Cultivate Conference", which is said to be the UK's only business growth summit focussed exclusively on the rural and agricultural sectors. Given the UK was in a significant time of legislative change, what I had expected was a range of speakers with a wealth of information on the industry's political climate, changing policies and an update on the evolving Environmental Land Management Scheme (ELMS) and the impacts it would likely have on rural growth.

What the conference was, in reality, was much different yet far better. In fact, the day was truly inspirational. I struggled at the time to find any immediate link to the conference speakers and my project title, however the connection came much later as I pondered some of the challenges we face in achieving a sustainable farming system. We often focus our attention to the environmental and economic pillars of sustainability, yet society will have to play a pivotal role in reversing our climate emergency. With this in mind, we must remember that good leadership, vision and focus are needed.

### Leadership - Marcus Child

Whilst the afternoon was focused around building resilience and identity within our food and farming brands, the conference began with a truly exceptional two-hour session titled "The Big Reset" by motivational speaker Marcus Child.

Since listening to Marcus, I often think of his key messages and his recordings have become my go-to resources for student induction and group tutorials when inspiration and motivation is needed. Amongst many ideas, his idea that one must have a picture on the wall and work towards realising that picture is a strong one, at both an individual and institutional level.

A story he tells so well is one of celebrity Bear Grylls as a young man, laid in a military rehabilitation hospital with a broken back, unable to move. Bear asked his father for the poster of Mount Everest which had been on his bedroom wall as a child. Once on the wall of his hospital room, he looked at this daily and took great motivation from it, determined to one day climb to the top. Apparently, none of the nurses thought this was a bad idea as they knew it gave hope. With that picture and glimmer of hope, Bear Grylls became the youngest Briton to climb to the summit of Mount Everest at the age of just twenty-three.

*"Is the picture big enough? Are we asking something of ourselves which is properly big enough. The brain is like a super computer. Ask small questions, get small answers. Ask massive questions, the whole thing won't rest until it gets there" – Marcus Child*

As well as self-drive and vision, another key theme in the session was effective leadership and management, and the ability to motivate people to make good decisions. In his career, Marcus has worked with many senior leaders in the corporate world to drive positive change and transformation in big multi-national companies. Government policy, labour shortages and climate change are just a few examples of ongoing pressures in agriculture, all of which will require us to change our ways of working further. Similarly, if we are to drive social and cultural change to the benefit of our environment, strong leadership will be needed to take people on a journey, often in a direction unknown to them. On this basis, I have since reflected positively on the relevance of this conference to both the sustainability agenda and my own personal development as a leader and teaching practitioner.

*"When one person gets a picture - that's interesting. Two people get a picture, they share it, they fall in love, let's put our dreams together - you get more than the power of one plus one" – (Marcus Child)*

## IAgrM National Farm Management Conference 2022

The Institute of Agricultural Management held their annual conference at the QEII centre in London on 1st November 2022. The conference title was "*Agriculture's Defining Decade: Balancing Food and Environmental Security*" and had a line-up of tremendous speakers such as Professor Tim Lang, Professor John Gilliland and Head of Rural Research at Savills, Emily Norton.

### Arial LiDAR - Professor John Gilliland

Professor John Gilliland is a Professor of Practice at Queens University Belfast and Director of Agriculture and Sustainability at Devenish. His experience in the industry as a farmer, coupled with his work in developing and implementing environmental policy, makes him a true asset to the ongoing drive for sustainability. At the conference, Professor Gilliland shared progress on a £45million Soil Nutrient Health Scheme (SNHS) in Northern Ireland (NI), funded by the Department of Agriculture, Environment and Rural Affairs.

LiDAR, an acronym for "light detection and ranging", is an active remote sensing technology which can measure landscape features. In practice, this technology operates through the use of laser lights which reflect off of objects, returning to the laser, creating what is referred to as a wave form. These peaks in light intensity represent objects on the ground such as hedges and trees. For decades LiDAR has been used to generate topography maps although has since been used for the collection of environmental data, for example vegetation structures, such as forest canopy height and cover, leaf area index and in some cases even species identification.

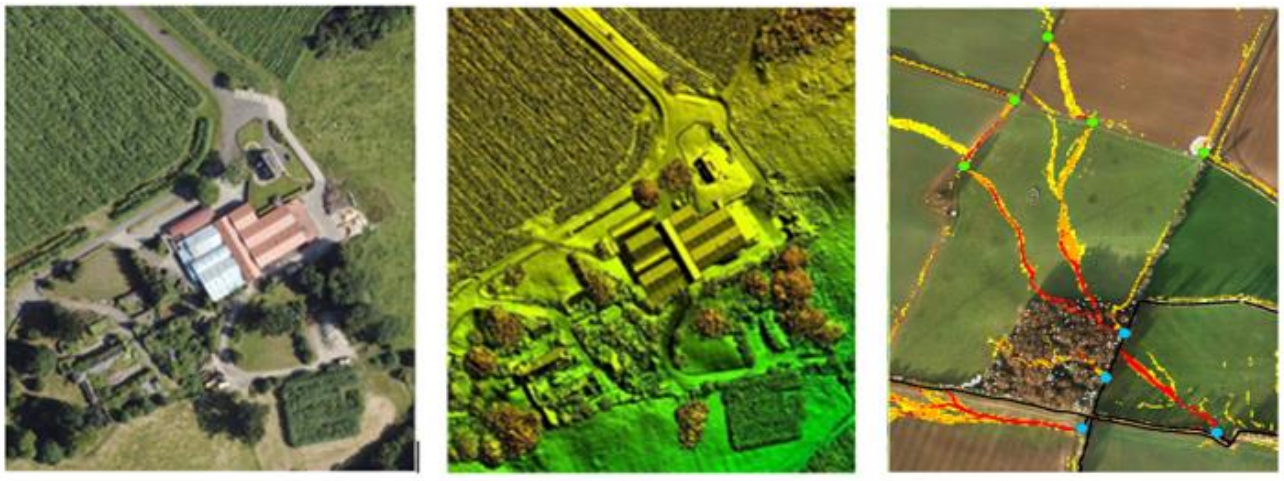

*Figure 8: Comparison of an ordinary photograph compared to LiDAR (Van Rees, 2021) and example of identified hydrologically sensitive area map (Thomas et al., 2016)*

For the benefit of water quality and soil degradation prevention, LiDAR has been used to identify critical source areas (CSAs) of diffuse pollution in agricultural catchments by identifying hydrologically

sensitive areas (HSAs), as seen in Figure 8 (Thomas et al., 2016). Although CSAs can be identified through other cheaper means, LiDAR provides a quick method of data collection when attempting to undertake landscape-scale assessments. Using this data, data informed mitigations such as wider grass margins can be implemented to reduce loss of soil nutrients and sediment. As well as its potential for reducing water pollution and soil erosion, its potential to measure carbon stocks in soils, trees and hedges could make it a useful tool for improving carbon auditing and baselining.

LiDAR is playing a critical role in NI's current Soil Nutrient Health Scheme which has so far been rolled out in one of four zones, with registration due to open in July 2023 for zone two. The scheme is the result of great success in a number of different pilot studies which took place from 2017 to 2019, covering approximately 6.3% of Northern Irish farms (Okumah et al., 2019). The pilot study in Upper Bann included the use of LiDAR and yielded positive behavioural change in the way farmers conducted their nutrient management. For example, 77.6% of farmers have now used runoff risk maps to make decisions around buffer strips whilst many had noted that the risk maps had also increased their awareness of land mineral content and are now considering ground conditions at application far more than they did previously.

## Alternative Insect Protein – Dr Thomas Farrugia

Dr Farrugia's presentation was part of a panel discussion alongside other new business start-ups however stood out as being particularly different and emerging. Beta Bugs Ltd is an insect genetics company which develops and distributes insect genetics, namely black solider fly, to commercial insect farmers. The audience was particularly interested in this, which was surprising as anecdotally I had always thought perceptions of insect protein amongst the agricultural industry was poor. Whilst I would consider the use of insect protein largely radical in the context of current practices at this point in time, there is a wealth of literature highlighting its potential for growth in the future and thought it worth a mention. I find its potential in pig and poultry industries, in particular, a huge opportunity as their reliance on cereal crops in the absence of a rumen to effectively utilise forages, will continue to be a factor creating feed-food competition with humans.

The insect protein is derived from valorisation of food wastes which means it has a low carbon footprint. The integration of vertical farming principles into insect production systems similar to those seen in the plant industry has resulted in high density protein production without the need for vast swathes of land. Production systems can vary in size hugely and although full sized commercial systems produce tonnes of protein per day, even small-scale containerised systems can achieve several tonnes of protein per month in minimal space. Certainly food for thought and an area for further exploration.

## Project Value

Over the past two years I have thoroughly enjoyed participating in the wide range of CPD outlined in this report with the aim to:

1. Identify sustainable agricultural practices aligned with the underlying principles associated with certified organic, regenerative and similar low-input production systems
2. Evaluate the ecosystems services delivered by these agricultural practices
3. Determine the suitability of these practises for adoption by conventional farms
4. Collect case studies of good practice to inform and enhance teaching practice

There is simply too much to share, however it was overwhelmingly evident that soil would continue to be a critical area of research as the climate crisis worsens. Integrating soil-positive management practices on livestock farms, with the support of the latest science and technology, will be critical in restoring our ecosystems and reverse the decline in biodiversity. The 22nd World Congress of Soil Science was a particular highlight in this regard and has provided me with several excellent examples of positive transformation in the way we can manage soils through improved data and decision making.

Another highlight of this project was the opportunity to visit Woodland Valley Farm in Cornwall. As well as being host to a wide range of good environmental practices, their work with the beaver rewilding opened my eyes in a direction I had not once considered. Chris' approach to conservation and agriculture would likely appeal to my students too, therefore could be an ideal opportunity for a field trip.

I know for certain that these practices and case studies will be impactful in the future as they have already had a significant impact on my teaching and proved an excellent source of inspiration during the development of UCR's Sustainable Agriculture degrees. The whole experience has really emphasised to me the importance of scholarly activity and I hope this report inspires you to engage in your own area of scholarship.

I encourage you to look at opportunities through charitable organisations and other funding bodies to fund your scholarly activity. TFCCT is just one of many that the agricultural industry has the advantage of being beneficiary of, and of the several scholarship and training opportunities provided by the TFCCT, the Agricultural Educators Award specifically targets those in agricultural education. Whether your discipline area is agriculture or other sectors of education, capitalising on opportunities such as the Agricultural Educators Award will support you in developing your teaching practice to ensure that our students of today regenerate our planet of tomorrow.

## Reference List

AHDB. (2022). Supporting the journey towards net zero. AHDB, Kenilworth Supporting the journey towards net zero | AHDB

Auster, R. A., Puttock, A. & Brazier, R. (2019). Unravelling perceptions of Eurasian beaver reintroduction in Great Britain. *Area*, 52, 364-375

Cardinale, B. J., Wright, J. P., Cadotte M. W., Carroll, I. T., Hector, A. & Srivastava, D.S. (2007). Impacts of plant diversity on biomass production increase through time because of species complementarity. *PNAS*, 104, 46, 18123-18128

Defra. (2022). National Statistics Chapter 12: Organic farming. Defra, London. Chapter 12: Organic farming - GOV.UK (www.gov.uk)#

European Environment Agency. (2018). *Agricultural Land: Nitrogen Balance.*

FAO. 2015. Status of the World's Soil Resources. Food and Agriculture Organisation of the United Nations, Rome

Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. (2013). Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities. Rome: FAO. http://www.fao.org/3/a-i3437e.pdf

Grace, C., Boland, T. M., Sheridan, H., Lott, S., Brennan, E., Fritch, R. & Lynch, M. B. (2018). The effect of increasing pasture species on herbage production, chemical composition and utilisation under intensive sheep grazing. *Grass and Forage Science*, 73, 1, 852-864

Grange, G., Finn, F. A. & Brophy, C. (2021). Plant diversity enhanced yield and mitigated drought impacts in intensively managed grassland communities. *Journal of Applied Ecology*, 58, 1864-1875

Gray, B. (2020) *Beavers help battle ongoing drought*. Climate Change, Northwestern University. https://climatechange.medill.northwestern.edu/2015/06/25/battle-born-beaver-tale/

Grossi, G., Goglio, P., Vitali, A. & Williams, A. G. (2019). Livestock and climate change: impact of livestock on climate and mitigation strategies. *Animal Frontiers*, 9, 11, 69-76

Jaramillo, D. M., Sheridan, H., Soder, K. & Dubeux, J. C. B. (2021). Enhancing the sustainability of temperate pasture systems through more diverse swards. *Agronomy*, 11, 1-14

Kozlowski, D. F., Hall, R. K., Swanson, S. R. & Heggem, D. T. (2016). Linking management and riparian physical functions to water quality and aquatic habitat. *Journal of Water Resource and Protection*, 8, 797-815 http://dx.doi.org/10.4236/jwarp.2016.88065

Luscher, A., Mueller-Harvey, I., Soussana, J. F., Rees, R. M. & Preyraud, J. L. (2014). Potential of legume-based grassland-livestock systems in Europe: A review. *Grass and Forage Science*, 69, 2, 206-228

McCarthy, K. M., McAloon, C. G., Lynch, M. B., Pierce, K. M. & Mulligan, F. J. (2020). Herb species inclusion in grazing swards for dairy cows – A systematic review and meta-analysis. *Journal of Dairy Science*, 103, 2, 1460-1430

McNally, S. R., Laughlin, D. C., Rutledge, S., Dodd, M. B., Six, J. and Schipper, L. A. (2015). Root carbon inputs under modestly diverse sward and conventional ryegrass-clover pasture: implications for soil carbon sequestration. *Plant Soil*, 392, 289-299

Okumah, M., Martin-Ortega, J., Chapman, P., Lyon, C. & Novo, P. (2019). Behavioural impacts of Northern Ireland's Soil Sampling and Training Schemes 2017-2019. A Rephokus report project. http://wp.lancs.ac.uk/rephokus/

Pemberton, K. G., Hills, J. L., Freeman, M. J., McLaren, D. K., French, M. & Rawnsley, R. P. (2016). More milk from forage: Milk production, blood metabolites, and forage intake of dairy cows grazing pasture mixtures and spatially adjacent monocultures. *Journal of Dairy Science*, 99, 3512-3528

Peyraud, J. L., Le Gall, A. & Luscher, A. (2009). Potential food production from forage legume-based-systems in Europe: an overview. *Irish Journal of Agricultural and Food Research*, 48, 115-135

Poore, J. and Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, 360, 6392, 987-992

Price, J. P., Siriwardena, G. M., Williams, A. P., Alison, J. & Williams, J. R. (2017). Annex 2: Sward Management. In *Environment and Rural Affairs Monitoring & Modelling Programme: Sustainable Farming Scheme Evidence Review.* Centre for Ecology and Hydrology

Puttock, A., Graham, H. A., Ashe, J., Luscombe, D. & Brazier, R. E. (2020). Beaver dams attenuate flow: A multi-site study. Hydrological Processes, 35, 2, 1-18

Riviero, M. J., Balocchi, O. L., Neumann, F. L. & Siebald, J. A., (2019). Grazing performance of dairy cows and pasture productivity for different cultivars of perennial ryegrass under contrasting managements. *Animals (Basel),* 9, 253

Savills. (2021). Regenerative Agriculture. Savills UK Rural. https://pdf.euro.savills.co.uk/uk/rural---other/spotlight---regenerative-agriculture-2021.pdf

Scottish Government. (2022). Report on the Welfare of Beavers in Scotland. Scottish Animal Welfare Commission, Edinburgh. Report on the Welfare of Beavers in Scotland Scottish Animal Welfare Commission (www.gov.scot)

Shader, C., Miller, A. & Scialabba, N., E. (2013). Sustainability and Organic Livestock Modelling (SOL-m): Impacts of a global upscaling of low-input and organic livestock production - preliminary results. FAO, Rome https://www.fao.org/3/aq381e/aq381e.pdf

Shader, C., Muller, A., Scialabba, N. E., Hecht, J., Isensee, A., Erb, K., Smith, P., Makkar, H. P. S., Klocke, P., Leiver, F., Schwegler, P., Stoize, M. & Niggli, U. (2015). Impacts of feeding less food-competing feedstuffs to livestock on global food system sustainability. *Journal of the Royal Society Interface,* 12, 1-12. https://royalsocietypublishing.org/doi/full/10.1098/rsif.2015.0891

Sleugh, B., Moore, K. J., George, J. R. and Brummer, E. C. (2000). Binary legume-grass mixtures improve forage yield, quality and seasonal distribution. *Journal of Agronomy*, 92, 24-29

Smith, L. G., Jones, P. J., Kirk, G. J. D., Pearce, B, D. & Williams, A. G. (2018). Modelling the production impacts of a widespread conversion to organic agriculture in England and Wales. *Land Use Policy*, 76, 391-404

Thomas, I. A., Jordan, P., Mellander, P. E., Fenton, O., Shine, O., D. Uallacháin, Ó h., Creamer, R., McDonald, N. T., Dunlop, P. & Murphy, P. N. C. (2016). Improving the identification of hydrologically sensitive areas using LiDAR DEMs for the delineation and mitigation of critical source areas of diffuse pollution. *Science of the Total Environment*, 556, 276-290

Thornton, P. K., Van de Steeg, J., Notenbaert, A. & Herrero, M. (2009). The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. *Agricultural Systems*, 101, 113-127

Van Rees, E. (2021). Bluesky LiDAR Benchmarks Carbon Neutral Farming in Northern Ireland. Geo Connexion. https://www.geoconnexion.com/news/bluesky-lidar-benchmarks-carbon-neutral-farming-in-northern-ireland

Westermeier, P., Wosnitza, A., Willner, E., Feuerstein, U., Luesink, E., Schulze, A., Schum, A. & Hartmann, S. (2016). Variation in drought tolerance of Perennial Ryegrass (*Lolium perenne L.*). *Breeding in a World of Scarcity* 63-68

Whenua, M. (2020). Management of grazed landscapes to increase soil carbon stocks in temperate, dryland grasslands. *Frontiers in Sustainable Food Systems*, 4, 1-7

Wiltshire, J., Martineau, H.& Jenkins, R. (2019). *A framework for benchmarking greenhouse gas emissions intensity in Scottish farming*. Ricardo Energy & Environment, Scotland A framework for benchmarking greenhouse gas emissions intensity in Scottish farming (climatexchange.org.uk)

Zaralis, K., Zollitsch, W., Measures, M. & Padel, S. (2016). *Technical Note 3: Use of diverse swards and "mob grazing" for forage production*. SOLID. https://farmadvice.solidairy.eu/wp-content/uploads/2016/05/SOLID_technical_note3_diverseswards.pdf