A Just Transition Business Case:

For Farmers, Animals, and the Environment

Contents

We're World Animal Protection. We're here to end animal cruelty and suffering. Forever. Putting animals first isn't just better for them, it's vital for us and for our shared planet. It will take the combined power of people, companies, and governments to tackle the broken systems that cause animal suffering. Together, we can transform the lives of farmed and wild animals around the world.

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Cover image: Dual-purpose chickens forage for food outside their "arc". Credit: World Animal Protection.

Executive Summary

About World Animal Protection

World Animal Protection has been fighting for a better life for all the world's animals for over 70 years. We're a global movement working to end factory farming and replace it with fair farming that benefits animals, people, and the planet.

Our Just Transition project aims to work with farmers, to bring an end to cruel intensive farming practices, while working towards a sustainable, resilient, and humane food system.

We want to replace factory farming with nature-friendly, higher-welfare farming that benefits animals, people, and the planet. We're working towards a future where all farmed animals are treated with dignity and respect.

World Animal Protection wants to support consumers and farmers to ensure every farmed animal has a good life and everyone has access to high quality food that has been humanely reared.

Photo: A woolly mangalitza pig at Brodoclea Woodland Farm, North Ayrshire. Credit: World Animal Protection

The Business Case for a Just Transition

The UK agriculture sector stands at a critical juncture, facing simultaneous challenges of climate change, biodiversity loss, animal welfare concerns, and economic pressures on farmers. This report presents evidence-based pathways for transitioning from intensive animal agriculture to low-input systems which improve financial resilience for farmers and provide better outcomes for the climate and animals, with a particular focus on the benefits of integrating trees into pasture.

Through detailed case studies of pioneering UK farms, we demonstrate that housing animals in woodland and implementing holistic planned grazing can simultaneously improve animal welfare, enhance environmental outcomes, and improve farm profitability. These approaches reduce dependency on expensive inputs (such as fertilisers and antibiotics), while creating new revenue streams through ecosystem services, such as carbon sequestration. Real-world economic examples are provided, to demonstrate the multiple ways to meet the National Food Strategy's goals of improving the quality of food, while keeping costs lower for consumers.

The interventions are cost-effective, can be introduced on most animal farms, and if centrally supported, the benefits are so pronounced we would expect uptake to be high. There are existing farming enterprises with compelling economic and environmental evidence bases, representing *low-input models which are ready to be scaled-out. There is evidence that this shift from High-Input-High-Output (HIHO) to Low-Input-Low-Output (LILO) farming practices can be profitable in the medium term, in addition to increasing a series of social and environmental benefits while increasing food security.

This report presents the case that by pivoting farm payments towards low-input silvopasture, it will be possible to produce higher-welfare food with positive environmental impacts for a comparable price to factory farmed meat, without requiring an increase in investment, or increasing the price of food.

*See Glossary on page 8.

Photo: Walking with farmer Clare Hill around Planton Farm, Shropshire. Credit: World Animal Protection

Key Findings

1. Recommendations from the National Food Strategy (Dimbleby, 2021), *i.e.,* that we should eat "less but better" animal products, can be done without increasing the price of food, by offsetting products costs with ecosystem services.

2. The price differential between sustainably produced and conventional animal products is smaller than commonly assumed. For example, Brodoclea Woodland Farm in North Ayrshire, is a high-welfare farm achieving price parity with factory-farmed pork which would require only £113 per acre in ecosystem service payments – significantly less than many existing agricultural subsidies.

3. Silvopastoral and holistic planned grazing practices can deliver multiple benefits:

   - Improved animal welfare through natural behaviours and reduced disease pressure
   - Enhanced carbon sequestration and biodiversity
   - Reduced input costs and increased farm resilience
   - Creation of new revenue streams through ecosystem services

4. Current policy frameworks often inadvertently exclude innovative farming practices from support mechanisms. For instance, many agroforestry grants are designed for cattle but exclude pigs and poultry, despite evidence of their potential benefits in woodland systems.

5. True cost accounting, which factors in environmental and social benefits, reveals that regenerative farming systems can be more economically viable than conventional approaches when ecosystem services are properly valued.

Photo: Free-range chickens foraging outdoors at Planton Farm, Shropshire. Credit: World Animal Protection

Key Policy Recommendations

- Create evidence-led policies which allow animals to live a good life, restore the ecosystem, and create more resilient farm businesses.
- Adapt existing subsidy schemes to incentivise both the housing of animals in woodland, and the planting of woodland in permanent pasture.
- Develop flexible payment mechanisms that open up mixed-species agroforestry.
- Create structures to help farmers realise the value of ecosystem services, e.g., nature markets and true-cost carbon accounting.
- Support the transition to extensive farming systems through targeted funding and technical assistance.

Photo: A herd of pasture-fed Hereford cows at Romshed Farm, Kent. Credit: World Animal Protection

What is a Just Transition?

A just transition for agriculture refers to the process of transforming food and farming systems to become more sustainable and equitable while ensuring that farmers, farm workers, rural communities, and animals are supported throughout the change.

At its core, a just transition recognises that agriculture needs to shift away from practices that contribute to climate change, biodiversity loss, animal suffering, and food insecurity. However, this shift must be managed in a way that protects and empowers the people who depend on current agricultural systems for their livelihoods.

At present, the majority of UK farmers working in animal agriculture make very little money for their work, threaten their local environment through pollutants, and contribute to global runaway climate change through deforestation overseas to produce animal feed. All this while providing a life of suffering for farmed animals who are housed inside.

This report makes the case, based on case studies of real innovative farms who are operating in the UK, that housing animals outside, under trees, can be transformative for animal health, farm economics, and allow us to move towards the "have it all" scenario in the National Food Strategy (Dimbleby, 2021).

Photo: Two pigs in a woodland area at Planton Farm, Shropshire. Credit: World Animal Protection.

Glossary

Agriculture and Horticulture Development Board (AHDB)	A statutory levy board funded by farmers, growers, and others in the supply chain to help the British agriculture and horticulture sectors improve their competitiveness and sustainability through research, knowledge transfer, market development and promotional activities.
Agroecology	A holistic and integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of sustainable agriculture and food systems. It seeks to optimise the interactions between plants, animals, humans, and the environment while also addressing the need for socially equitable food systems within which people can exercise choice over what they eat and how and where it is produced (Food and Agriculture Organisation (FAO) definition). Agroecology is concurrently a science, a set of practices and a social movement and has evolved as a concept over recent decades to expand in scope from a focus on fields and farms to encompass the entirety of agriculture and food systems. It now represents a transdisciplinary field that includes the ecological, socio-cultural, technological, economic, and political dimensions of food systems, from production to consumption.
Carbon sequestration	Farm carbon sequestration is the process by which agricultural lands capture and store carbon dioxide from the atmosphere in soil and plant biomass. This happens when plants photosynthesise and transfer carbon into the soil through their roots. Farming practices like holistic planned grazing can increase the rate of soil creation, and therefore, the carbon that is sequestered.
Ecosystem service	Ecosystem services from farms are the natural benefits and functions that agricultural landscapes provide to humans and the environment beyond just food production. These services include pollination by beneficial insects, natural pest control from predatory species, soil formation and fertility maintenance through biological processes, water filtration and retention in soil, and carbon storage in plants and soil organic matter. Sustainable and diversified farming systems typically support more services than intensive monocultures. These services have real economic value even though they're often not directly paid for in traditional markets.

Extensive agriculture	Extensive agriculture operates across larger land areas with minimal inputs and lower yields per acre, typically relying more on natural processes and existing environmental conditions rather than inputs. These farming methods usually involve practices like grazing on natural pastures, rotating crops across large fields, or managing forests for timber, requiring less labour and capital per unit area but usually more total land to achieve profitable production levels.
Factory farm farming system	Confines animals for the purpose of profit at the expense of animal welfare. Requires routine mutilation, fast growth breeds and restriction of natural behaviours
Farm Gate Price	The market value of an agricultural product minus the selling costs
Food forest	A food forest is a multi-layered, perennial gardening system that mimics the structure and beneficial relationships of a natural forest ecosystem while focusing on food-producing species, including animals in the understory.
Food systems	Food systems gather all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, gathering, processing, marketing, distribution, preparation, consumption and disposal of food, and the output of these activities, including health, socio-economic, animal welfare, and environmental outcomes.
High-Input-High-Output (HIHO)	A farming model where product is maximised through high application of inputs, *e.g.,* fertilisers. HIHO systems allow small land parcels to be productive in isolation, but are dependent on the continued application of inputs which have to be brought in. This system is characterised by high revenues, but correspondingly high costs. Usually, environmental costs are externalised.
Holistic planned grazing	A livestock management system that mimics natural herd movements by concentrating animals in small areas for short periods, followed by long recovery periods that allow plants to regrow fully before being grazed again.
Intensive agriculture	Maximises output from a relatively small land area through heavy use of inputs like fertilisers, antimicrobials, and machinery. This farming approach typically requires significant capital investment and can produce very high yields per unit of land but

	is usually associated with low resilience and environmental degradation.
Just Transition	A just transition away from an industrial livestock system involves supporting those who stand to lose economically – especially farmers – to support them to continue trading. This is both to create structures that encourage and reward them for delivering public goods, and to prevent them from becoming jobless following a collapse of ecological or economic farm systems.
Low-Input-Low-Output (LILO)	A farming model which aims to maximise the resilience of a farming system, even if it produces less output as a result. External inputs are minimised and replaced with free or circular alternatives. This can be more profitable for the farmer than HIHO farming because costs are reduced, and increased resilience makes the farm more able to absorb market shocks. LILO systems also produce more diverse products (e.g., higher-welfare meat) which come with marketing opportunities. Additionally, LILO systems produce (often undervalued) ecosystem services.
Regenerative agriculture	Describes farming and grazing practices that, among other benefits, reverse climate change by rebuilding soil organic matter and restoring degraded soil biodiversity – resulting in both carbon drawdown and improvement to the water cycle.
Silvopasture	The practice of grazing animals under/among trees.
Stable Organic Carbon (SOC)	This is carbon which is "locked". Roots of plants are stable, because they are not exposed to air, so can't off-gas as carbon dioxide. The upper material of plants is not stable, and in the full lifespan of the plant, they will decompose and re-enter the environment as carbon dioxide.
True cost accounting	This is where everything is accounted for, and nothing is externalised. *E.g.*, a business which makes £1m profit, but produces £2m worth of pollution, is profitable if the cost of pollution is externalised, but is not profitable under a true cost accounting.
True cost carbon accounting	This is where carbon costs are included in a true cost accounting. *E.g.*, a profitable factory farm, which uses food that is grown on deforested land in the Amazon, might not be profitable if the cost of carbon is accounted for. Likewise, a regenerative farm which is not profitable but is sequestering carbon, might be profitable if it is able to realise the "true cost" of that ecosystem service.

The Theory

The theory of change for a Just Transition for Agriculture is to extensify farming, taking animals out of confinement systems such as barns and cages, and placing them in natural environments, where input costs such as feed can be replaced by natural ecosystem processes.

The Agriculture and Horticulture Development Board (AHDB) states that in Q1 2024 the average industrially-produced pig generated £16 of profit (Corsair, 2024), which is about 10% of a highly variable farmgate price (AHDB, 2024). Broiler chickens operate at an even slimmer profit margin, being around 5%. 60-70% of production price for these animals is feed, around 10% tends to be vet visits, and the cost of housing carbon emissions for feed production etc., are vast, and tend to be externalised from accountings. The high capital costs required to house, feed, and process these animals means that farm businesses lack resilience and mobility. Farm businesses are so intensified that they struggle to pivot away from dependency on any input, putting them in a highly precarious situation and prone to financial shocks due to price rises of inputs, e.g., feed costs and diesel. Any policy change, e.g., around antibiotics, can also shock a farm business which is dependent on that input for its processes.

Every farm business is different, but this report highlights interventions which are currently being done in the UK. These can be implemented on many farms, and can affray the costs of production, while improving animal health and the environmental impacts.

Critically, the price difference between this ethical, regeneratively produced food, and factory farmed food, is relatively small. There are a number of ways to reduce this difference; eating "less but better" meat, as specified by the Climate Change Committee, who say that meat consumption needs to fall by 20-50% by 2050 for the UK to meet its net zero commitments. But so could any number of new revenue streams, such as ecosystem services, which this report focuses on.

These solutions are with-market, which means that they represent a viable intervention for farmers without depending on central funding from subsidies. But widening subsidy eligibility could increase uptake without requiring further government investment. There is a critical role for policy interventions here: farmers are currently failing to benefit from nature markets, such as carbon offset schemes, nutrient neutrality in housing development, and biodiversity net gain, despite these schemes being undersubscribed. Many existing subsidy schemes are not flexible enough to accommodate farms which are clearly candidates for the goals of these programmes, for example, pigs and chickens not being included in agroforestry grant schemes. It's clear that a legislative intervention could increase uptake of these sustainable farming practices and ease consumer doubts over a price hike for animal products.

Photo: Woolly mangalitza piglets at Brodoclea Woodland Farm, North Ayrshire. Credit: David Carruth

Policy Landscapes

At present, there are a number of opportunities, challenges, and threats to higher-welfare farming systems in each of the four UK nations.

Wales

The Sustainable Land Management (SLM) objectives of the Agriculture (Wales) Act 2023 requires all farmers participating in the Sustainable Farming Scheme (SFS) are required to carry out a suite of 'Universal Actions' in order to receive the 'Universal Baseline Payment'. This includes "at least 10% under tree cover as woodland or individual trees"(Welsh Parliament Senedd, 2024). "Create new woodland and agro-forestry" is one of several proposed Universal Actions currently being considered for inclusion in the SLM.

The most common argument against the "10% rule" in Wales is that it risks taking land out of production with associated concerns regarding business viability and food security. Another argument is that planting trees, when paired with another obligatory 10% universal action for biodiversity, risks taking 20% of land out of agricultural use. However, as this report illustrates, putting land into sustainable management does not necessarily mean taking it out of food production, and planting trees can improve food production and financial security. This policy has been met with public protest, and risks becoming watered down. The 2024 consultation changes the requirement so that it would not be 10% of the entire holding, but 10% of the remaining area once unsuitable areas have been identified. Clarity from the Senedd that this land can remain in use, and potentially meet both woodland and biodiversity aims through a well-managed silvopasture scheme, would be helpful.

This scheme could be developed towards tripartite wins. E.g., natural successional regeneration can develop high-habitat woodland in a way that both benefits farm operations and maximises biodiversity gains.

Scotland

Scotland has committed to continue the European-style Basic-Payment-Scheme (BPS) payments but shifting the ratio of payments away from universal "Pillar 1" payments, and towards "Pillar 2" payments, which pay farmers for innovating, and developing their land management.

The current Agricultural Reform route keeps most payments schemes the same, including Agri-Environment and Climate Schemes (AECS) with reviews planned for 2027.

Scotland does have a Forestry Grant Scheme with an Agroforestry option.

Correspondence with parliamentarians as part of this research project reveals that, despite ambiguity in the wording preventing animals other than cattle from being able to receive payments, "The current FGS Agroforestry option can accommodate pigs", and the guidance is expected to change presently to reflect this. However, the maximum planting density will remain at 400 stems per hectare, as any further planting would constitute the creation of a woodland, which is regulated separately. This means that, pending the change in guidance and proliferation of this information to woodland creation officers, those practicing porcine silvopasture will be able to benefit from ongoing agroforestry payments, but only if their woodland is populated with stems at cattle-appropriate densities.

There are clearly opportunities to modify these payment structures to close the price gap for producing animals through silvopasture. At present, this scheme pays £3,600 per hectare capital payment for the establishment of trees, and £400 per hectare for 5 years thereafter, a total disbursement of £5600 per hectare. Spreading this grant out over a longer period could encourage active management, rather than the establishment and abandonment of woodland. Structured correctly, using the Brodoclea Farm case study (see below), this disbursement could close the price gap between Brodoclea Farm pork and factory farmed pork, for ten years, all while having an ecosystem services impact which is five times greater than existing schemes.

The more these schemes can be made to be flexible, to encourage the placement of animals in existing single-use woodland, and to diversify single-use pasture, the better.

England

England is phasing out the Basic Payments Scheme (BPS) and replacing it with an Environmental Land Management (ELM) scheme, which is currently being co-developed by farmers. This transition will be complete by 2027.

ELM has three main strands:

- Sustainable Farming Incentive (SFI) - "universal" (unlimited) payments for managing land in a demonstrably sustainable way.
- Countryside Stewardship Scheme (CSS) - non-universal (limited, competitive) payments to support nature recovery.
- Landscape Recovery Scheme (LRS) - large-scale project support, usually envisioned for multiple farms across a catchment.

The SFI does have two agroforestry schemes, AGF1 and AGF2, both of which are pitched as "very low density", meaning 51-130 stems/ha. The guidance is pitched towards productive trees rather than extensive systems, as demonstrated by being wary of 'poaching' the fruit by cattle. Similarly, to Scotland, these schemes are ostensibly species-agnostic, but in practice, there is no evidence of structural support for non-cattle animals in these schemes, and the schemes are undersubscribed.

In February, the CSS released four higher-tier agroforestry actions which do allow for higher-density planting (CAFG1; 2; 3; 4). CAFG1 is the highest density, paying £849 per hectare per year for ten years, so representing a high relative disbursement, but "high density" is still defined as "251 to 400 trees per hectare... usually planted in rows, or a grid". If this was adapted to allow pig-levels of tree planting, far more environmental benefits could be unlocked per hectare.

Northern Ireland

Northern Ireland represents an emerging policy area. The collapse of the Assembly at Stormont from 2022-2024 meant there was no functioning devolved government to develop and approve agricultural policy reforms. The new government is faced with the challenge of navigating the post-Brexit situation in Ireland, including the Windsor Framework, meaning they have to align themselves with both European and UK regulations.

The post-Brexit and post-restoration of Stormont context actually presents a significant opportunity. As Northern Ireland develops its agricultural policy framework, it has the chance to integrate agroforestry from the ground up rather than retrofitting it into existing schemes.

A key policy lever exists through Northern Ireland's climate legislation. The Climate Change Act (Northern Ireland) 2022 sets a target for net zero by 2050 and requires the development of Climate Action Plans. Agroforestry could be positioned as a vital tool for achieving these targets while maintaining agricultural productivity. The Forests For Our Future programme, which aims to increase woodland cover in Northern Ireland, could be expanded to explicitly include agroforestry systems.

Photo: Brodoclea Woodland Farm, North Ayrshire, Scotland.
Credit: World Animal Protection

Photo: Romshed Farm, Kent.
Credit: World Animal Protection

Carbon Impacts and Funding Potential of Forest Farms

A true-cost carbon accounting of animal production ought to consider not only the carbon cost of animal feed production, but also, the costs and benefits of the diet on methane emissions, and the counterfactual cost of not using the land to sequester carbon through other means.

Methane is a by-product of enteric fermentation in the gut of the cattle and changing feed composition can dramatically change the amount of methane produced during digestion of ruminants (Li et al., 2018; Roque et al., 2019; Glasson et al., 2022). Rumen fermentation has a variety of genetic factors, with more feed efficient cattle producing less methane per kilogram of product, but much of the variation is attributable to diet (Beauchemin, McAllister and McGinn, 2009). Methanogenic microorganisms thrive in a sugar-rich diet, such as is common on a diet of ryegrass found on most farms. Introducing variety in the diet, which can either be through food additives, or by widening access to forage, increases the quality of enteric fermentation and reduces methane substantially (Molina-Botero et al., 2024). There are additive solutions in the market, such as Asparagopsis feed mixes, which aim to solve the fermentation problem in cattle, but each of these solutions 1) have shock-price-fragility as a marketable input, and 2) have associated carbon costs with production, packaging, etc.

The biggest potential carbon benefit of eating less meat is the opportunity to repurpose land to sequester carbon[15]

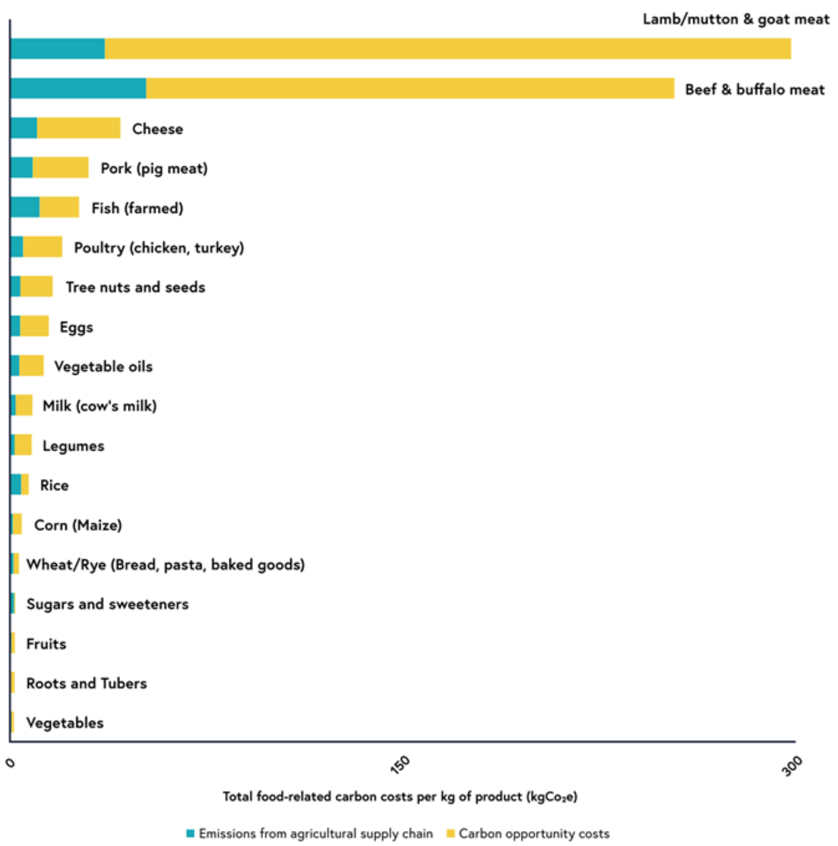

Figure 1. A graph demonstrating the carbon costs of single-use pasture. Reforesting this land reduces the opportunity cost (yellow) by allowing carbon sequestration to happen on land being used to produce food.

Another important consideration is the counterfactual impact of single-use grassland. The graph, from (Dimbleby, 2021) drawing on data from (Searchinger et al., 2018) shows that the overall emissions from production are dwarfed if we account for the wasted potential of not repurposing grassland for carbon sequestration. This is one reason that silvopasture is so promising as an intervention: by housing animals under trees, we not only increase welfare, but also, there is a huge untapped potential for sequestering.

Brodoclea, a pig farm based in Ayrshire, raises mangalitza pigs, which are smaller than the average factory breed. They are raised in a Future Forest Company site, a business which allows people to purchase carbon offsetting in a planted woodland.

At present, the farm sells direct to consumer for £6.20/kg of pork products. The pigs have a hang weight of 70kg, as opposed to the larger 93kg of HIHO pigs. This price gap is relatively small, and there are a number of policy interventions which could allow consumers to buy pork produced under this system for the same price as factory farmed meat. The code used to calculate this as appendix 1, but in order to achieve price parity with factory farmed meat, Brodoclea Farm needs to close a gap of £243 per pig.

It's possible that this could be passed on to the consumer. Eating less, but better meat is part of the recommended National Food Strategy (Dimbleby, 2021). The average UK household annual spend on processed meats is £376 - a budget which buys 184kg of factory farmed pork, or 60.6kg of Brodoclea Farm pork. Processing the meat into charcuterie would increase its value, so could endorsing Dimbleby-style consumer strategies around spending more on less, but higher-quality, meat. Selling direct-to-consumer allows farmers to do more of their own marketing and depend less on pricing structures set by supermarkets (Dimbleby, 2021).

However, the consumer need not be impacted, if subsidies, or structures around carbon and ecosystems services are properly managed. £243 per head is less than the basic payments, or delinked payments, for any farmed animal.

Additionally, if this cost is indexed against the acre of land, instead of by head of stock, Brodoclea Farm only need to generate £113 per acre to achieve price parity with factory farmed pork. Pigs are an important part of the regeneration of woodland, clearing bracken, turning the earth to create habitat, and clearing the understory to allow the growth of new saplings.

NB that the forest needs to be fairly established before the introduction of pigs, but trees can be planted at a much higher concentration, as the pigs don't mind if the canopy closes (which would prevent grass growth, required for grazing animals). Brodoclea Farm's productive woodland is planted at 1400-1800 stems per hectare, with buffer strips of 2,500 per hectare, but current schemes pay for 400 stems per hectare, or less.

Adapting this subsidy to include pig systems would allow more carbon to be sequestered, and more meat to be produced per pound spent, than existing payments aimed at cattle.

Existing agroforestry grant support (for cattle) is £2100/acre, with ongoing payments of £50/acre per year. If this was increased proportionally in relation to the creation of stems and spread out through the life of the grant rather than frontloaded in a way which encourages the creation and abandonment of single-use woodland, the agroforestry payment could more than pay for the price gap. Additionally, this would incentivise the use of forestry for food production, instead of encouraging abandonment of single-use woodland.

This report has identified several other businesses looking at bolt-on silvopasture systems, such as Romshed farm in Kent which grazes cows on tree strips, and Planton Farm's Impeckable project, which is rearing multi-use chickens in a food forest. Additional income streams could be developed by the intensification of carbon sequestration, but this industry is nascent. Developing a good-food carbon sequestration funding stream could be a significant policy lever for transitioning to economically and environmentally sustainable farming.

Pivoting farm funding, where we no longer allow factory farmers to externalise the carbon cost of feed production overseas, and where we allow regenerative farmers to cash-in on the carbon sequestration implicit to regenerative systems, would allow the British public to enjoy higher-welfare meat without paying a price premium. The price gap is so low that this could be achieved by changing any one of a number of farming payments, or ELM schemes.

Photo: A Mangalitza pig and her piglets on Brodoclea Woodland Farm, North Ayrshire. Credit: World Animal Protection.

Just Transition: A Theory of Change

In order to create a just transition for farmers, animals, and the environment, we need to create economic pathways for farm businesses to transition to become more extensive, more diverse, and less dependent on inputs. What follows are a series of case studies of British farms which are innovating in ways which could, with the right information dissemination, be scaled-out to other farms.

Common techniques on these farms are:

1. Diversify away from improved breeds and towards heritage breeds.
2. Developing multiple uses for, and income streams from, each land parcel.
3. Strategic planning of ecosystem activities, e.g., grazing, in order to maximise nutrient cycling on the farm.

Developing silvopasture is a promising intervention, both by placing animals under existing woodland (as in Sawreydykes, Brodoclea, and Romshed), and through planting new trees on otherwise permanent pasture (Planton). Many farms have existing woodland areas, left over from previous AECS schemes, or deployed as riparian strips for wind buffering or nutrient filtering, which could be used for forage or housing.

Another common feature is that these farms are struggling to access structures which might reward them for provision of ecosystem services. Increasing biodiversity, producing higher-quality food, and sequestering carbon, are all in lines with the food and carbon strategies of the UK and its devolved nations. At present, agricultural innovators give these away for free, and are so far ahead of the curve they usually cannot benefit from existing funding schemes. Meanwhile, factory farms are able to avoid paying the true cost of their carbon pollution, by driving deforestation to produce animal feed, emissions which the IPCC estimate to be 15% of all anthropogenic greenhouse gasses (International Panel on Climate Change, 2019). A shift towards true-cost accounting, including central schemes which evaluate and reward farmers for delivering public goods, will open up revenues for developing farms towards profitable, sustainable production of good food. Often this will be either a pivot of an existing fund, to be more flexible and reflect the diversity of farming practice in the UK, or a discrete funding opportunity which allows the transition of farm businesses to a more extensive and resilient operating model.

Photo: Romshed Farm, Kent, which uses a number of low-cost innovations to improve animal health and biodiversity.
Credit: World Animal Protection.

Case Studies

Brodoclea Woodland Farm

Brodoclea Woodland Farm is a pig farm nested within an existing woodland operation, which mob grazes Mangalitza pigs, a 'woolly' variety which are rarely seen in the UK. This is an agroforestry system, where the pigs are moved between 21 paddocks of mixed woodland in order to forage, with the products being meat, timber, and carbon capture.

This farm is situated within a Future Forest Company (FFC) woodland. This is a carbon capture enterprise, which offers tree planting and carbon credits investors and corporate sponsors. This woodland has also been supported by a Scottish Woodland Creation grant. The two staff members, David Carruth and Ken Porter, are employed by the FFC. The targets are that the enterprise will support 75% of David's wage and 50% of Ken's wage, but as managers in the FFC, both wages are higher than the market rate for agriculturalists. The farm sells direct-to-consumer through its website, and can charge £6.20/kilo, which is around double the rate for conventional pork products. The farm also sells pigs to other conservation projects.

The pigs were not originally in the business plan of the woodland and have been retroactively proposed as an additional revenue stream for the holding. The forest is planted at a high density of stems, at around 1500 per hectare. The woodland is 8-12 years old, and a mixture of native broadleaf species, with shelter strips of Norwegian spruce (labelled 'S' and coloured pink on the site chart). The old farmhouse, and a small wind farm, border the holding.

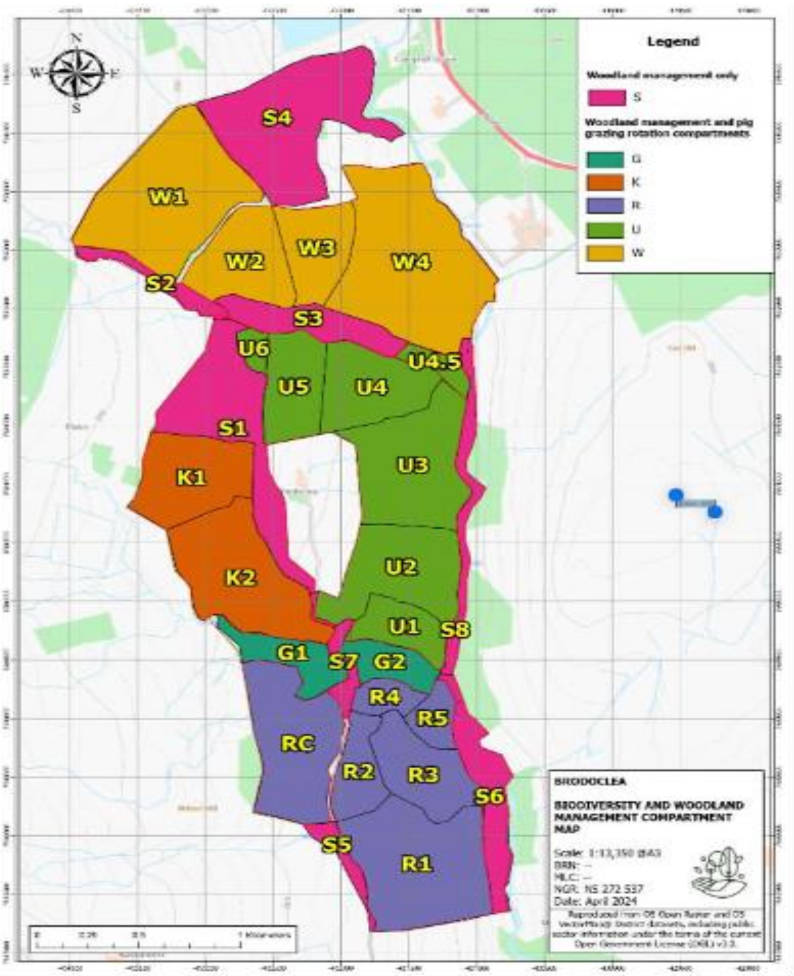

Figure 2. A map of Brodoclea woodland farm. Each enclosure is a wooded area that the pigs are moved between periodically to forage. This allows the land is to rest, and restock the food supply, when the pigs are elsewhere.

The potential here, and why this project is so exciting, is that woodland pigs could be a bolt-on enterprise to any number of other woodland enterprises, which are currently single-use land parcels. This could provide higher-welfare animal lives, more resilient native food, and ecosystem services to the woodland.

FFC's strategy is to create old-growth-style woodland, with 140 different species, which are initially interplanted in rows, but allowed to spread and self-seed outside of the rows. The pigs provide ecosystem services which aid the forestry process by rutting the land, which creates a specific habitat which encourages water retention, and disrupts/encourages the growth of certain tree species. They also serve as bracken control, which can clear the understory for new tree growth, preventing the bracken from outcompeting tree seedlings, and for building up material for wildfires. Pigs rut in the winter, revealing foodstuffs in the soil for birds and other small animals. From the crest of the hill, the holding is visibly more diverse in species variety, and tree age, than any other surrounding land parcel.

The grazing plan is adaptive to the conditions, which means that instead of being moved daily like ruminants on pasture, the pigs are moved when the conditions are suitable, and allowed to linger if they are viewed to be doing well. A very mixed diet is available in the woodland, allowing for user-led forage. Pigs are very selective eaters, for example, they are able to avoid bracken poisoning by selectively eating certain sections of the rhizome. Adaptive transfer of grazing means that the pigs are allowed to remain in paddocks where they are showing interest. As a rule of thumb, the pigs are moved every 2/3 weeks, and when the land is around 60% grazed or mulched.

Carruth, who manages the project, identifies that the calorific needs of the pigs are 97% met through forage in the summer, and 80% through the winter. This is supplemented by feed of his own mix, constituted of sugar beet and dark grain. This is soy-free. Pregnant sows are fed 'sow rolls', special feed for gestation and suckling which does contain 2% GMO soy, as no alternative has been identified. Carruth notes that while using soy, which is produced through deforestation, is a contradiction for this project, it's worth it, because feeding the sows a protein-rich mix improves the condition of the piglets, both by improving the nutritional quality of the milk, and also, by reducing the need for the mother to leave the nest to forage. This leaves the piglets less prone to predation and exposure.

Photo: Farmer David Carruth demonstrates out-of-control bracken in an ungrazed area. Pigs eat the bracken roots, allowing trees to self-seed in the understory. Credit: World Animal Protection.

Photo: A pigs nest, one of many natural behaviours pigs can only express when kept outside. Pigs do not need teeth removing or tails clipped when raised in a nest, instead of a crate. Credit: World Animal Protection.

Nesting is one of several natural behaviours that pigs are able to express in woodland. Pigs make ground nests with their mouths, cutting grass and reeds to form a bowl which piglets are not able to climb out of. In the left-hand photo, piglets can be seen sheltering in the wall of the nest, because it was lightly raining, and their mother was feeding nearby. Mutilation of the pigs often seen in factory farms, by means of teeth cutting, castration, nose ringing, etc., are not required in this setting, as the environmental factors that these interventions solve (e.g., overcrowding) are not an issue in the forestry system. The pigs are free to move around their (large) pens of 20 acres each, and respond well to visitors, who they have learnt to associate with friendly behaviour and food. There is evidence of wallows being made for bathing. The pigs coparent, and the piglets can move between mothers in the family group. Male pigs can be kept in their own paddock. This represents the natural behaviour of pigs, as male pigs are solitary, only seeking out females during mating season. Competition for females can produce conspecific violence, but the males are happy to be housed together in the absence of females.

It is worth noting that the breed is docile. Brodoclea Farm has attempted to mix in some wild boar genetics to the breed, but found this made the animal's temperament less amenable, to little benefit.

Brodoclea Farm has a vet plan, and their own welfare outcome assessment, which Carruth does on his daily rounds. Carruth reports that pig mortality is negligible, with only one loss of an animal after six weeks. They have never had to call a vet out to site. Carruth ascribes this to the resilience of the breed, and good biosecurity for the site curbing the exposure to contagious disease. There are no wild boars in Ayrshire, and the pigs are not taken out to markets or shows, and the breed stock is vertically integrated. The breed shows resistance to ticks and parasites, due to their dense hair, and wide forage range. Visitors are encouraged to wash their boots with disinfectant. Infant mortality can be a hidden statistic – pregnant pigs can travel to find a site they prefer to make their nest, and it took three days to find a pregnant sow's nest when we were visiting. Sows can eat stillborn young, so there could be hidden stock losses. Birds of prey are a concern, however, keeping the mother close to the nest and tree cover appear to mitigate this risk. The farm currently has 83 adults and 23 piglets. If the land manager's assessment that no pig has required a vet in the farm's four years of operation is correct, this represents a significant success for animal health, and for costs saved from the lack of vet fees.

In terms of cost, the main capital investment for this enterprise is fencing, which can cost up to £30/metre to install. Pigs are very strong, and are able to either rut underneath fences, or use their noses to tear out fence posts, so specialised fences might be required. Many forestry enterprises will have deer fencing, which is tall, but might not be suitably strong in its ground attachment for use with adult pigs. The integrity of existing fencing should be prioritised when considering this as a bolt-on enterprise. Brodoclea Farm experimented with electric fences, which appears viable in some holdings, but staff struggled with the strimming requirements, as any grass which grows high enough to touch the electric tape earths the fence and renders it ineffective. They settled on a new larch fence, with an attached bottom wire, and high tensile Rylock, which is pig resistant. Some newer deer fencing on site also appears to be pig resistant. Cost was saved by milling the fence posts from wood produced on site. The capital costs of fencing can be substantial and represent a significant challenge in any agribusiness. However, it is worth noting that the paddocks in Brodoclea Farm does not appear to be entirely secure, with several pigs appearing where they were not meant to be or escaping into other paddocks for nest building. The land managers feed the pigs daily in the paddock they're meant to be in, which might be a contributor to them not wandering off too far.

Our conversation with Carruth identified several policy opportunities.

17 of schedule 1 of the Welfare of Farmed Animals (Scotland) Regulations 2010 states that "Animals not kept in buildings must, where necessary and possible, be given protection from adverse weather conditions". This guidance, coupled with training, led Carruth to build shelters in each land parcel, but Carruth notes these are very rarely used by the pigs. This could be because trees provide sufficient shelter to satisfy the pigs. Another potential policy adjustment could be in the realm of agroforestry grants. Current schemes are pitched at less than 400 stems per hectare, which is where the canopy begins to join up, and the pasture beneath fails. An agroforestry system for pigs, which don't require as much pasture, would benefit from a different density. Brodoclea Farm is planted at 1500 stems per hectare.

Additionally, it might be beneficial for grant schemes, such as the Woodland Carbon Code, to allow for retroactive applications. The woodland in Brodoclea Farm predates the scheme and can't benefit from it. Carruth also describes issues with certifying products as organic, as each of the many species would need to be individually certified, and the organic supply chain for trees is underdeveloped. One quote from Carruth which aptly sums up the issue of centralised grants trying to 'capture' the value produced by innovative businesses: "Legislation needs to be as flexible as the land is diverse".

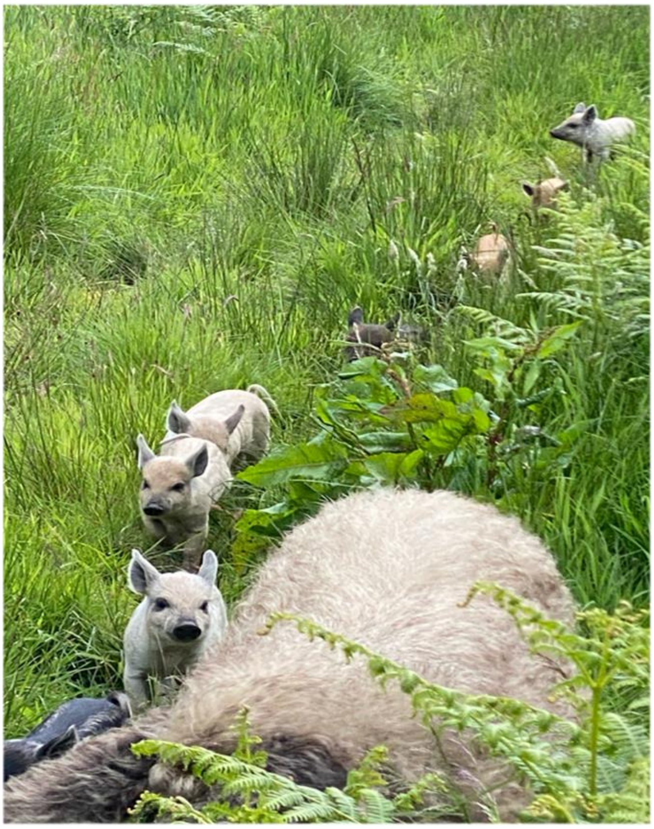

Photo: A sounder of piglets follow their mother. Credit: World Animal Protection.

Brodoclea Farm states that its pig enterprise is not currently a profitable business in-and-of itself, though it is close to break-even. As an independent business within the wood, the enterprise is externalising many benefits to the wider enterprise. If one was to factor in the timber, carbon, community, and ecosystem service co-products, assessing this as an integrated and holistic system, would change the profitability assessment.

There are also several things which could be done to increase profitability. The farm makes good use of social media for direct-to-consumer sales, and notes that there would be business opportunities by further processing the meat (e.g., into charcuterie) or exporting meat. At present it is sold in 'drops' online at a price point which is deflated by conventional pricing expectations. It is worth noting that the carrying capacity of the land is higher, and it seems possible to have more animals there without compromising the welfare of the animals. Daily checks and feeding, while positive for welfare and overall, a good thing, are more frequent than most animals on the hill, and could probably be reduced without negatively impacting production. This can be challenging as pigs of different ages require different levels of staff attention, but the short estrus cycle of pigs means that clever timing of fertilisation could keep this work predictable. Brodoclea Farm has 430 acres of land but has only ever housed 200 pigs at most. An enterprise could have a much higher stocking density without compromising welfare, especially if located in a non-productive woodland, where stocking density could be higher without impacting a timber business.

Photo: Adult mangalitza pigs forage for food. Credit: David Carruth.

Notably, the price gap between Brodoclea Farm pigs and factory farmed pigs is not that great, with a delta of £3.10 per kg. With the smaller Mangalitza pigs having a hang weight of 70kg, the farm would have to produce an additional £434 per pig to bring them to price parity with factory farmed pork. This is exciting from a food systems perspective, as (for the site of Brodoclea Farm) this would only take £186 per acre to bring the pigs to parity.

Brodoclea Farm is currently not quantifying the carbon sequestration, biodiversity benefits, and other ecosystem services of their pigs, and acknowledges there is a research gap here. If the pigs can be shown to have a tangible benefit for carbon sequestration, or site regeneration, this is a premium that the Future Forest Company could pass on to its customers. In short: Brodoclea Farm could be making the case that the pigs should be paid to be on site. £186 per acre is not a lot of money compared to some payment schemes (NB there are no basic payments available for pigs) – extent agroforestry grant support (for cattle) is £2100/acre, with ongoing payments of £50/acre per year, and these have half as many stems per acre as pigs require.

The case can be made that current agroforestry payments encourage abandonment of woodland and do little to cover the ongoing costs of maintaining wood once it has been planted. A new generation of silvopasture for pigs could produce vastly more benefits, including more trees, reasonably priced good food, and better lives for animals – at a comparable cost.

The strong public demand for higher-welfare pork products, and resilience of the pigs to key industrial disease, makes woolly pigs a promising bolt-on to existing enterprises, which can add a new income stream to land which is currently single-use.

Planton Farm; Impeckable Chicken

Planton Farm is an integrated multi-species farm based in Shropshire, England. Run by Clare Hill and Annie Rayner, formerly of Oxford University, they farm pigs, chickens, and cattle using holistic planned grazing. Planton are deploying three particularly interesting interventions: 1. Mobile chicken arcs, 2. Food forests, and 3. Dual-purpose chickens.

Mobile Chicken Arcs

Planton houses chickens in mobile "arcs", a housing solution which is on sleds, and can be dragged from place to place by a tractor. This is situated within an electric netting for predator control. This has several benefits: the chickens are free to forage the ground, reducing their feed requirements, and the arc allows for mobile field fertilisation, or for the collection of bedding to be spread where required. Chickens reliably only produce effluent at night, allowing their nitrogenous waste to go where required.

Mobile arcs provide birds with continuous access to fresh pasture as the structure gets moved regularly across the land. This closely mimics chickens' natural foraging behaviour, allowing them to scratch for insects, seeds, and fresh vegetation. The birds benefit from a diverse, natural diet while enjoying protection from predators and weather extremes under the arc's shelter.

Mobile arcs require less initial investment than permanent structures, (with some American innovators making them out of old caravans with the floors cut out) and their mobility allows farmers to maximise land use efficiency. By rotating chickens across different pastures, farmers can integrate them into broader farming systems – for instance, following grazing cattle to break up manure pats and reduce fly populations.

Photo: A mobile chicken "arc" which can be dragged on its skis. Credit: World Animal Protection.

Food Forest

Planton is in the process of planting a food forest, rows of trees have been planted, with space between to drag the chicken arcs. This paddock has a permanent predator fence, allowing chickens to move freely in the hectare. Planted at 200 stems/ha - Planton are planting a mixture of fruit and nut trees, including early and late flowing trees, to attract pollinators. The biological intensification will provide insect-life for the chickens to eat. Chickens eagerly consume insects, grubs, and weed seeds, helping to reduce pest populations without chemical interventions. This is especially valuable in orchards or gardens where pest pressure can be significant.

Feed typically represents about 60-70% of the total cost of producing a factory farmed chicken, with "improved" breeds (sometimes called Frankenchickens) requiring a formulated feed. The more of the feed process which can be outsourced to a forest, mimicking the natural foraging behaviours of chickens' ancestors in the wild, the more this cost is affrayed.

The economics become even more favourable when considering niche market opportunities. Many consumers are increasingly interested in heritage breeds and traditional farming methods.

Planton currently does not do direct-to-consumer sales, and their batch size is limited by how many chickens can fit on their trailer to the abattoir. Investment into these infrastructures has been shown to be effective in other farms in this business case.

Dual-Purpose Chicken Breeds

Planton is home to the Impeckable project, a DEFRA-funded programme which is exploring the viability of chicken breeds which are useful for both eggs and meat. Highly improved chicken breeds are typically used for only one or the other.

These breeds, such as Rhode Island Red, provide both eggs during their productive laying years and quality meat when their egg production naturally declines. From an economic perspective, this dual functionality creates multiple revenue streams from a single investment. A farmer who raises dual-purpose chickens first benefits from egg production, and then can sell the chickens for meat. From an economic perspective, these breeds offer flexibility for small-scale farmers and homesteaders. Instead of needing separate flocks for egg production and meat birds, a single flock can serve both purposes.

Photo: Farmer Clare Hill points out the newly planted trees in Planton's chicken food forest. Credit: World Animal Protection.

This reduces initial investment costs, simplifies management, and allows farmers to adapt to changing market conditions. When egg prices are high, they can focus on egg production; when meat prices rise, they can process excess roosters or older hens for meat.

From a welfare perspective, there are multiple benefits - male chicks are finished at 20 weeks and aren't culled at birth like in intensive systems. These chickens are also more resilient to disease. Currently only a handful of single use breeds make up the majority of chickens in the UK. These chickens suffer multiple poor welfare outcomes due to genetic selection for profitability with fast growth causing ligament problems and organ failure leading to high mortality rates and low mobility which in turn causes hock burns and foot pad dermatitis, painful disfiguring ailments that can be easily avoided by using slower growing breeds that can freely move about once fully grown. Low mobility also necessitates the use of confinement systems such as barn and cages meaning large numbers (thousands) are kept in close proximity, this coupled with genetic uniformity and high levels of stress due to the conditions they are kept in increase the risk of disease spread through whole herds.

Romshed Farm

Romshed farm, near Sevenoaks, Kent, deploys a number of low-cost innovations to improve animal health and biodiversity, which can be implemented on most pastures.

Holistic Planned Grazing

Romshed deploys holistic planned grazing, called 'Mob' grazing, or HPG. This involves splitting a large field into several smaller paddocks using electric fencing and moving the cattle day-to-day. This can all be achieved with a few hundred pounds worth of electric fencing, which is used to make the ad-hoc paddocks.

This has a number of benefits: Cattle are selective eaters and will graze all new growth first. This allows them to eat their preferred foods, while giving the plants time to rest, regrow, and put down deep roots, which are critical for grassland health and carbon sequestration. Romshed manages the cattle, so each field 'strip' allows the cows access to trees - cattle prefer to browse woody forage as part of their diet. Several features taken as granted for cows in modern systems, including sloppy faeces and high methane output, are a result of them being fed a limited diet of sugary grass. When cattle are free to forage, they eat a more balanced diet which produces less methane - as it is a by-product of improper enteric fermentation. Cattle will readily browse trees when available, and depending on the seasonal availability of grass, will opt to consume 15-30% of their diet as woody forage.

The frequent movement of cattle also reduces their exposure to parasites, as parasitic larvae typically need about 7-10 days to become infective after eggs are deposited in manure. Romshed cycle sheep and cattle alternatively, as their parasites are non-communicable, and report a greatly reduced parasite burden as a result.

Romshed are also trialling fenceless collars - which use a combination of loud sounds and electric shocks to limit the cattle to sections of a field. This can be used to house animals where electric fencing would be infeasible for whatever reason. Romshed are able to charge landowners for the ecosystem services of housing their cattle on their land, as they top fields which could otherwise be overrun by rushes.

Another critical environmental benefit comes from the way this grazing method affects plant species diversity. When animals move frequently, they don't have time to selectively graze only their favourite plants.

Photo: Romshed's herd of Hereford cattle. The electric fence separates them from tomorrow' grass. The difference in grass length shows the impact the herd can have in a single day. Credit: World Animal Protection.

This prevents the gradual loss of desirable species that often occurs under continuous grazing. Instead, an increase in plant diversity is produced, which creates more resilient ecosystems and better wildlife habitat.

The carbon sequestration potential of holistic planned grazing is substantial. Healthy grasslands managed this way can sequester significant amounts of atmospheric carbon in their soil, potentially helping to mitigate climate change. This happens through the constant cycle of grazing, plant recovery, and root growth that builds organic matter in the soil.

This system also improves water cycles in the environment. Better soil structure and increased organic matter led to improved water infiltration and storage. This reduces runoff and erosion while increasing drought resilience. In many cases, springs and streams that had dried up begin flowing again as the watershed health improves.

Photo: A Romshed calf grazes woody forage from a tree, wearing a "fenceless" collar. Credit: World Animal Protection.

Sawreydykes Plantation

Fluke Control

Sawreydykes deploys strategic grazing management to control fluke levels by moving sheep between pastures depending on temperature. Fluke, a parasitic trematode, occupies the liver of sheep, causing acute health problems. Simply put, eggs present in sheep faeces (and passing through a snail intermediary host) grow into new parasites that attach themselves to grass, waiting to infect future sheep. This process takes around 24 weeks in total and is susceptible to climate conditions at every stage: cold weather can kill eggs, dry conditions can prevent miracidia from swimming, and excessive heat can destroy metacercaria on pasture.

Eggs remain dormant through winter, and wake when temperatures reach 10°C. At this time, risk factors for fluke pressure include short grass (indicating sheep activity in the previous year), and wet ground (where snails can congregate). Because Sawreydykes covers a range of elevations, with close attention to temperature, once a paddock reaches the 10°C, the sheep can be moved to higher ground, where the fluke will still be dormant. Similarly, the sheep can be moved to dry pastures, avoiding standing water, which attracts snails. The presence of curlews, oystercatchers, and geese on coastal pastures additionally assist in the treatment of fluke. Sawreydykes do faecal egg counts, and liver analysis from the abattoir, and report lower levels of fluke since they started strategic grazing management.

Photo: A pig shelter behind fencing which (while suitable for pigs) won't keep out wild deer, who act as a reservoir for disease.
Credit: World Animal Protection.

Photo: Sawreydykes's rare breed sheep graze on species-rich grassland in Cumbria. Credit: World Animal Protection.

Dormant Pig Silvopasture

Sawreydykes has an upper plantation area made of semi-ancient woodland, which formerly housed a silvopasture pig operation. They used to house 14 pigs in two paddocks and have the infrastructure (shelters etc). Sawreydykes report that their paddocks fell out of compliance due to changing guidance on African Swine Fever, with increased monitoring in the area for ASF leading the vet to advise that improved fencing was required to make sure no deer could get into the enclosure. Sawreydykes, unable to fund improved fencing, ceased rearing pigs.

Sawreydykes currently post a £7-9k loss, which the farm managers offset against current salaries. Once they retire, they plan to rent out the land, unless they can find a way to bring the farm into profit. NB that, at Brodoclea Farm rates of profitability, 14 pigs would cover that loss. A discrete fund which covered the infrastructure costs of bringing the pig farm back into operation could allow the farm to continue to produce high welfare and higher quality food.

It is also worth noting that several existing Agri-Environment Climate Schemes have required the planting of woodland with improved fencing, meaning there will be plantations with potential to be converted to pig production, similar to how the Future Forest Company was able to bolt-on a pig business to its existing carbon-timber operation. Many businesses might find that they already have the fencing infrastructure to be raising pigs in dormant, vacant woodland under their management.

Câr-y-Môr

Câr-y-Môr operates an innovative marine farming system off the coast of St Davids, Pembrokeshire. Their vertical integrated multi-trophic aquaculture (VIMTA) system demonstrates how different species can be farmed together in a way that mimics natural ecosystem relationships. The farm operates by suspending ropes in the water column and seeding them with seaweed and shellfish.

The system works by cultivating multiple species at different trophic levels in the water column. At the base level, they grow various seaweed species including dulse and laver. Above these, they suspend mussels and oysters on longlines.

This vertical arrangement maximises the use of the water column while creating beneficial relationships between the species.

This system is fully extractive, meaning it filters nutrients out of the seawater, and does not require feeding. The seaweed products are currently processed into nitrogen-rich fertilisers, and (at the time of writing) the farm is developing direct-to-consumer marketing pathways for the shellfish, ready for a first harvest next year.

Extractive systems represent an exciting opportunity, as feed inputs are a major cost in terms of both farm carbon, and the cost-of-production. Seaweed and bivalves could be key players in the UK's sustainable food future.

Photo: Câr-y-Môr operating their innovative marine farming system off the coast of St Davids, Pembrokeshire. Credit: Câr-y-Môr (permission given to use)

Conclusions

This investigation into innovative UK farms demonstrates that a just transition in agriculture is not only possible but economically viable. If innovative, regenerative farmers are sufficiently supported, the UK can be making significant progress towards its climate commitments, and food strategy. Existing agricultural payments could be restructured to better support regenerative practices and reward ecosystem services.

Several clear pathways emerge for scaling these approaches:

1. Adaptation of existing woodland and agroforestry grants to accommodate a wider range of livestock species and management approaches.
2. Development of carbon and biodiversity payment mechanisms that properly value the ecosystem services provided by regenerative farming systems.
3. Support for farmer-led innovation in extensive farming systems, particularly around silvopasture and holistic planned grazing.
4. Reform of agricultural policies to recognise and reward the multiple benefits provided by integrated farming systems.

The success of farms like Brodoclea, Planton, and Romshed demonstrates that these approaches are practically achievable and can deliver simultaneous benefits for farmers, animals, and the environment.

The transition to more sustainable farming systems need not compromise food security or farmer livelihoods. Instead, by supporting innovative approaches to extensive farming, we can create a more resilient agricultural sector that delivers both high-quality food and essential ecosystem services.

Critical next steps include:

- Detailed economic analysis of ecosystem service valuation in regenerative farming systems.
- Development of practical guidance for farmers transitioning to extensive systems.
- Reform of agricultural payment schemes to better support integrated farming approaches.
- Creation of knowledge-sharing networks to spread successful practices.

By taking these steps, the UK can lead the way in demonstrating how agriculture can be transformed to meet the challenges of the 21st century while supporting farmer livelihoods and improving animal welfare.

Photo: A pig in woodland at Planton Farm, Shropshire. Credit: World Animal Protection.

Appendices:

1. Farming Models: HIHO vs. LILO

High-input-high-output farming (HIHO) is a model of production where sale-able outputs are maximised, even if this means a large number of expensive inputs are also required. This includes medicines such as antimicrobials, soil additives such as fertilisers and pesticides, major costs such as imported feed, as well as fairly innocuous dependencies, such as diesel, which market forces can balloon into significant on-farm expenses.

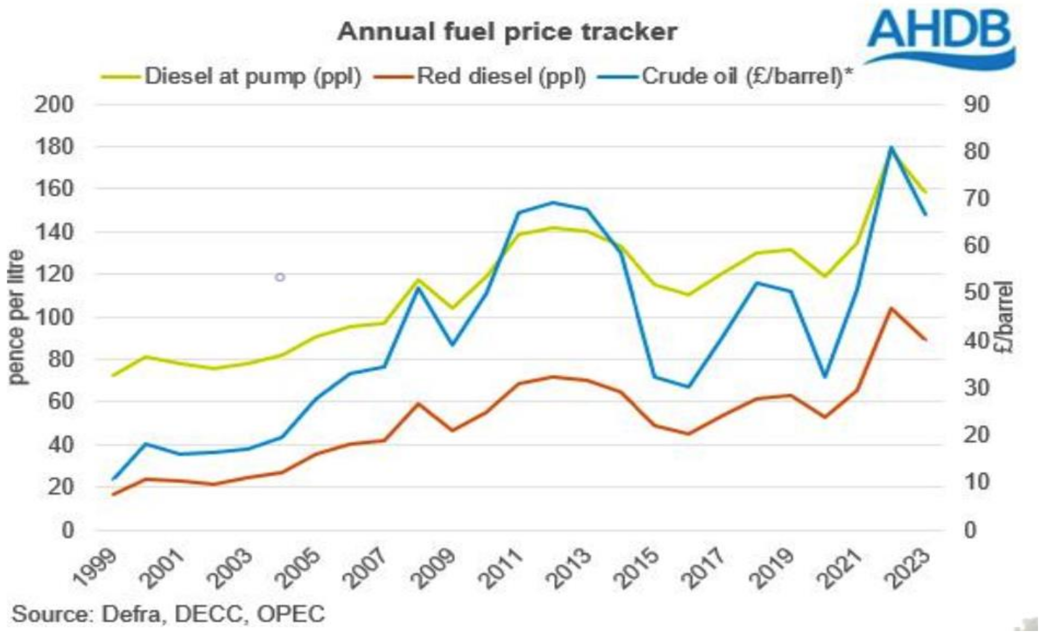

Figure 3. A graph showing the price volatility of Diesel, an essential input for virtually every farm.

Dependence on inputs such as red diesel, which the above graph shows experienced significant volatility over the past few years, creates a loss of resilience for the farm business. The relationship between inputs and profits have been highly theorised to try and arrive at the most profitable outcome (Roskam, Oude Lansink and Saatkamp, 2023), but as shown by the following example of pig prices, the rate of development of new economic pressures tends to outpace input innovation, trapping HIHO farms in increasingly marginal business models. Any farm which becomes ecologically dependent on, e.g. consistent treatments of a pesticide, antimicrobial, or any other input will become particularly susceptible to external market forces. These crises are baked-in to the logic of HIHO farming processes, (Hinchliffe et al., 2016), and intensive farming will almost certainly never arrive at a stable plateau where it is not responding to an emerging modality.

LILO, or low-input-low-output farming, is an alternative farming model where inputs are minimised, even if it reduces the sale-able quantity of outputs. The farm might produce a lower quantity of product, but it will generally be of higher quality and have far fewer economic dependencies. The AHDB states that in Q1 2024 the average factory-produced pig generated £16 of profit (Corsair, 2024), which is about 10% of a highly variable farmgate price (AHDB, 2024). 60-70% of production price is feed, around 10% tends to be vet visits, and the cost of housing, carbon, etc. tends to be externalised from these equations. This is highly precarious - if feed production increases by 10%, profit will be halved. If a new disease emerges and kills 10% of the sounder, profits will be eliminated entirely. The more that can be done to get feed, shelter, health, et cetera for free by housing the pigs outside, letting them forage, keeping them in lower densities, and anything else that is done hand-in-glove with nature for free, the more likely the operation is to be profitable. This also aids food security, as the farm is less susceptible to financial shocks due to changing input prices. Cameron et. al. find that the short-term profitability loss of allowing dairy cows to forage rather than being fed improved rations, is offset by the longer-term benefits of improved farm profitability through fewer expensive inputs, and unrealised savings in terms of carbon emissions (Cameron et al., 2018).

In HIHO farming animal wellbeing, carbon costs of feed production, ecosystem degradation, etc. are externalised. World Animal Protection would advocate for a move towards true cost accounting, where the value of human, environmental, and animal welfare improvements are realised in terms of payments to LILO farmers, and HIHO farmers pay the true cost of the carbon, antimicrobial resistance, inter alios they dump into the global commons (Chylinski et al., 2022; World Animal Protection, 2022, 2023, 2024) Schemes like the Food For Life scheme, a voluntary accreditation which coaches public institutions into producing good food, eating less meat, and sourcing their food locally, has been shown to have a variety of benefits to both individual health, and wider economics (Kersley and Knuutila, 2011). DEFRA has released a 'balanced scorecard' approach to procurement, which decentralises cost and considers a wider range of social and health factors (DEFRA, 2014). There is a huge, underutilised potential to move away from the Common Agricultural Policy model of primarily rewarding farmers for yield, no matter the costs.

Animals in lower stocking densities means the farm will produce less product, but it also has far lower costs in terms of housing and medicine, meaning the farm can be more profitable as a result (Cacek and Langner, 1986). LILO systems are always more resilient, as they are tied to the carrying capacity of the land, and allow the proper functioning of the immune systems, and the self-regulation of natural behaviours of the animals involved. LILO solutions produce less meat. However, they are also less reductive in terms of calories. At present 36% of global cereals are used as animal feed (Cassidy et al., 2013). The feed conversion ratio (FCR) of grain-fed farmed animals is low, usually around 10%, meaning that 90% of these calories are wasted. The United Nations Environment Programme (UNEP) identifies that these 'wasted' calories could, if the grain was fed directly to humans, feed 3.5 billion people (Nellemann, 2009). By returning these animals to a natural, grass-fed diet, instead of feeding them foods that humans can eat, the loss in meat production is vastly offset by the increase in available cereals for human consumption.

2. Farm Carbon in the UK: A Literature Review

Some of the best resources available for problematising this report is the Rothamsted Carbon Model (ROTHC), which models the turnover of organic carbon in topsoil over long timeframes (t=centuries) and builds of LINTUL, a model which is used to predict crop growth (Coleman et al., 2017, p. 3). (Jebari et al., 2024) provide a contemporary meta-analysis which provides an open-access dataset based on reviews of 52 UK-based studies. In summary: The improved carbon sequestration profile of properly grazed grassland is well-evidenced, and the evidence base for silvopasture is promising. Neither are currently fully accounted for in carbon audits.

A 2018 report by IDDRI, (Institute for Sustainable Development and International Relations) modelled a scenario for LILO agroecological uptake in Europe, where overall food production drops by 35%, carbon drops by 40%, and European consumption of local food increases (Poux and Aubert, 2018).

As identified by the Dimbleby report (Dimbleby, 2021), one of the biggest carbon costs in UK farming is the opportunity cost of not managing grasslands in a manner which maximises their carbon sequestration. This is a highly valuable but unrealised ecosystem service (Soussana and Lemaire, 2014; Jordon et al., 2024).

Overall, grassland has the potential to sequester 0.7 tonnes of carbon per hectare per year (Soussana and Lemaire, 2014). Carbon sequestration from holistically grazed grass has been shown to be almost double that of conventional grazing, being 128 vs 71 gC m^{-2} $year^{-1}$ respectively (Rasse, Rumpel and Dignac, 2005; Tallec and Blanfort, 2010) - with agroforestry having more potential still. Care must be taken while calculating this, as the relevant carbon is rooted within the soil, where it cannot off-gas when decomposing, and re-enter the atmosphere. Carbon 'locked' up in tree trunks through afforestation is short-lived and reversible if the trees are burnt or left to rot, but effectively sequestered if used in long-term projects like sustainable construction, where the carbon does not re-enter the environment.

There is ongoing debate around the potential for carbon sequestration in grassland, which is more effective in carbon-depleted grassland, and appears to taper off as the soil reaches its carbon carrying capacity (Garnett et al., 2017). Studies have shown that woodland is more capable than grasses in soil creation (which is isomorphic with decomposition speed), as well as maintaining a high carbon content in the soils created (Ashwood et al., 2019; Murphy et al., 2021).

Hill grazing has been identified as the lowest-carbon method for milk production, due its carbon sequestration potential, when silvopasture is not considered (Wilkinson, Chamberlain and Rivero, 2021). Wang identifies that soil composition of key nutrients is directly affected by grazing regime (Wang et al., 2024). Teague et al. indicate that grass cover under proper management is highly effective in reducing soil erosion and in increasing organic carbon stocks (Teague et al., 2016). Grazing at different grass heights (e.g.,11-18cm for sheep) has been shown to allow for carbon neutral ruminant production, due to the offset of stable carbon sequestered during root dieback (Savian et al., 2018). A meta-analysis of 115 studies showed that heavy grazing causes Carbon and Nitrogen losses, but rotational grazing (where the grass is left relatively long) reserved these losses into net C and N soil gains (Zhou et al., 2017). The academic consensus based on several reviews, as articulated in (Wang, 2019), is that "grazing lands may act as a net sink of emitted GHGs by sequestering carbon, and thus having a high potential to offset a substantial portion of GHG global mean forcing through the use of optimal grazing management" (Singer and Munns, 2001; McSherry and Ritchie, 2013; Abdalla et al., 2018; Wilson et al., 2018).

Goudling identifies a far greater Nitrogen carrying capacity in woodland soils compared to grassland, and that greater carbon content in the soil will prevent nitrogen off-gassing, meaning there is carrying capacity for greater carbon in British woodlands to prevent Nitrogenous greenhouse gas emissions (Goulding et al., 2001). (McTiernan et al., 2001) identify a relationship between matrix flow and carbon lost through absorption, where woodland soil profiles perform much better than grassland profiles.

Photo: Famer demonstrating the health of the soil at Romshed Farm.
Credit: World Animal Protection.

"For instance, in terms of GHG mitigation and SOC sequestration, forest regeneration on sheep pasture with natural regeneration or forest plantation showed a mitigation potential of up to 85 t CO 2 -eq ha −1 and 147 t CO 2 -eq ha −1 , respectively, over 25 years (O'Neill et al. 2020). Moreover, planting red alder trees into sheep-grazed pasture showed a CO 2 mitigation potential of 47.5 to 99 Mg C ha −1 , after 20 years, for different types of red alder trees (Nworji 2017). Likewise, land use feasibility of mitigation measures for agricultural greenhouse gas emissions in the UK. A change by either afforestation with species of broadleaf trees (planted at 800 or 1600 stems ha −1), or reversion to rough grassland, showed both soil N and C accumulation increasing SOC up to 46% and 334%, respectively, for 21 years (Baddeley et al. 2017). When pragmatically feasible, establishing hedgerows and field margins in arable landscapes and agroforestry systems could provide up to 63 t C ha −1 (Dunn et al. 2021). Similarly, Crous-Duran et al. (2020) using modelling showed that introducing trees in arable systems allowed the sequestration of up to ~400 t C ha−1 in high tree-density agroforestry systems. Likewise, Poulton et al. (2018) analysed rates of SOC increase in the treatments on 16 long-term experiments in the southeast UK. The latter study showed that the conversion from cropland to grassland or woodland enhanced SOC sequestration exceeding 4 per 1000 SOC stocks per year in the case of woodlands and reaching 55% in the case of grasslands.

More widely, under the European territory, agroforestry implementation in the priority areas (areas with the highest number of accumulated pressure), which made up 8.9% of total European farmland, would reduce between 1.4 and 43% of European agricultural GHG emissions, depending on the type of the agroforestry (Kay et al. 2019). In addition, several environmental impacts could be reduced under agroforestry systems due to microclimate amelioration through the windbreak effect of the trees, the conservation of soil and water, and wildlife habitats as well as the forest productivity and sustainability through C uptake, thereby GHG offsetting contributing to cross-sector net-zero targets (Nworji 2017; Jordon et al. 2020)." (Jebari et al., 2024, pp. 12–13)

Note bene that the profitability of silvopasture (without subsidies) depends on the high carrying potential of severely degenerated land, and a high carbon-market price. As soils become regenerated, or in the event of a softening of carbon markets, silvopasture will benefit from a funding structure which allow them to realise the ecosystem-service value of environmental externalities, such as biodiversity, food security, access, and other 'public goods' *(Garnett et al., 2017; Burgess and Rosati, 2018; Jordon et al., 2024).*

Each of these papers identify further research questions, demonstrating the state of emergence of regenerative agriculture. A review of the Rothamsted Institute's publications on farm carbon found low theoretical saturation, meaning that there is room for further inquiry. Nota bene that carbon sequestration is not routinely included in carbon accounting. Silvopasture, as a research frontier, is also excluded: A 2024 map analysis of soil carbon sequestration found a compelling body of evidence for grassland but excluded wooded pastures from the metanalysis (Rousset et al., 2024).

3. Brodoclea Woodland Farm Pricing Estimates

```
> #Brodoclea Woodland Farm price parity estimate
>
> #How much value would the current business need to generate as an ecosystem service,
> #in order to achieve price parity with factory farmed meat?
>
> price.kg.brodoclea.pork<-6.20
> print(price.kg.brodoclea.pork)
[1] 6.2
> hang.weight.kg.brodoclea<-70
> farmgate.price.pig<-(price.kg.brodoclea.pork*hang.weight.kg.brodoclea)
> print(farmgate.price.pig)
[1] 434
>
> brodoclea.acres<-430
> brodoclea.sounder<-200
> gdp.farm<-(brodoclea.sounder*farmgate.price.pig)
> print(gdp.farm)
[1] 86800
>
> #So farm is generating £434 per pig. They have 200 pigs over 430 acres.
> #Brodoclea is generating £86000 in income from pork product.
>
> gdp.acres.brodoclea<-gdp.farm/brodoclea.acres
> print(gdp.acres.brodoclea)
[1] 201.8605
>
> #£201 of pork product is produced per acre per year at Brodoclea.
>
> #Next is calculation of factory farmed pork, for comparisons sake.
> #Data is taken from https://ahdb.org.uk/pork/gb-deadweight-pig-prices-uk-spec, week end 12th Oct 2024
> #NB that this is cheaper, and pigs are harvested fatter. Mangoliza is a smaller breed
>
> price.kg.FF.pork<-2.04
> hang.weight.kg.FF.pork<-93.54
> FF.price.pig<-(price.kg.FF.pork*hang.weight.kg.FF.pork)
> print(FF.price.pig)
[1] 190.8216
```

```
> #FF pigs retail for £190. Brodoclea's pigs are £434.
>
> price.delta<-(farmgate.price.pig-FF.price.pig)
> print(price.delta)
[1] 243.1784
>
> #A FF pig is £243 cheaper than a Brodoclea pig.
> #But NB that FFs externalize the cost of carbon (importing soy feed, land use change overseas, inter alios)
> #And Brodoclea is currently not charging the Future Forest Company for the carbon it is sequestering, despite increasing regeneration
> #To calculate price parity:
>
> carbon.payment.requirement.parity<-(price.delta*brodoclea.sounder)/brodoclea.acres
> print(carbon.payment.requirement.parity)
[1] 113.1062
>
> #Brodoclea would only have to charge £113 per acre for ecosystem services for its pork products to achieve price parity with factory farmed meat.
```

(Borthwick, 2024)

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