Feeding Britain

from the Ground Up

Summary Report
December 2022

Sustainable Food Trust

sustainablefoodtrust.org

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Contents

Foreword

What should I eat to be healthy and sustainable? It's a question that more and more people are asking, but perhaps unsurprisingly, the dietary recommendations vary so much that many of us are utterly confused about how we should respond.

This report from the Sustainable Food Trust seeks to provide answers to that question, based on the presumption that, at least broadly, we should relate our future food consumption to the output of sustainable farming systems in the parts of the world in which we live.

Of course, context is everything and the launch of this report comes at what is a critical moment in agricultural history. As I write this, the Ukraine war continues to cause major disruptions to our farming and food systems, nationally and globally. It is likely that the conflict will have a permanent impact on the global trade of agricultural commodities, forcing us all to re-think the future of our food systems.

Most people now agree that increasing resilience and national food security is an absolute priority. But the question is, how should we achieve that? On the one hand, many advocate separating food production from nature, through further intensification of agriculture on the best land, sparing the more marginal areas for nature restoration. Conversely, others believe that we should take a less intensive approach, re-integrating food production with nature.

I started farming almost fifty years ago and right from the start, my aim was to produce food in harmony with nature. As a result, I find myself in the unusually privileged position of being able to witness the effect of a nature-based farming system on productivity over a long period. The results are surprisingly gratifying. Soil carbon stocks appear to be growing, yields are steadily increasing, and it is wonderful to witness the extent to which a wide range of wild plants, insects, birds and small mammals can coexist with a food production system which avoids the use of agrochemicals.

Through my experience, I have become increasingly convinced that farming systems based on this approach could be applied at scale. The steady increase in productivity over such a long period strongly indicates that the system works, in terms of its impacts on soil, plant, animal and human health. There are other benefits. In the current crisis, I am much less affected by the very high price of inputs, especially nitrogen fertiliser and animal feeds. My farm should also be in a better position to withstand the greater weather extremes that climate change is expected to bring.

However, these are merely personal observations and require validation if a case is to be made for biologically based systems to be more widely adopted. That's why we decided to commission this report, which we hope will go a long way to addressing the concerns of those who challenge the idea that farming in harmony with nature is a viable option at scale.

The first criticism — "your system could never feed the world" — reflects an understandable concern that a national or international transition to biologically based farming would simply not produce enough food, increasing our reliance on imports, offshoring our negative environmental and social impacts and leaving our own farmers vulnerable to being undercut by lower standard food produced overseas. This report builds on a growing body of evidence, which suggests that if we reduce food waste and change our diets, biologically based food production systems could provide us with enough food.

A second criticism, relating to the economic impact of such a transition, is that it would lead to a world of higher food prices. This leads to the question, how could we protect the right of every citizen to have access to high-quality, nourishing food, regardless of income level?

An important point is that current food prices are dishonest because they don't reflect the damage caused by intensive farming, so, if future food prices are to reflect the true cost of production, they will need to rise. In response to this, government will need to step in to support lower income groups, as we've recently seen with the energy crisis.

There is a third criticism, namely that people will be unwilling to change what they eat. However, we believe that many, maybe even most, informed citizens would be willing to adjust their diets to meet the current climate and nature challenges. Regardless of this, external events including the war in Ukraine and avian influenza are already having a major impact on the supply of many foods, including chicken and pork, with inevitable consequences for our diets, whether we like it or not.

We hope that this report will go some way towards demonstrating that if we switched to farming systems operating inside so called 'planetary boundaries', we would still be able to produce enough key staple foods to maintain current levels of self-sufficiency, providing we ate differently, ate less and wasted less. If we did this, a UK-wide farmland transition to sustainable and regenerative food production could enable our future farming and food systems to move from being part of the problem to being part of the solution.

Patrick Holden
CEO, Sustainable Food Trust

Executive summary

A UK-wide transition to sustainable and regenerative farming practices, to tackle the climate, nature and public health crises, could produce enough food to maintain and potentially even improve current levels of self-sufficiency, provided we ate differently, ate less and wasted less.

These are the key conclusions of our report, *Feeding Britain from the Ground Up*, which explores the potential impacts on land use, food production and individual diets of a UK-wide transition to sustainable farming based on biological principles.

IMPACTS ON LAND USE

Under our model:

— **Mixed farming:** There would be a general shift to mixed farming, resulting in the reintroduction of grassland and grazing livestock in arable areas (mainly in the south and east) and cropping in some areas which are currently dominated by grassland in the north and west of Britain.

— **Trees and land for nature:** Woodland cover would increase by close to a million hectares, and many more trees would be integrated into the farmed landscape through agroforestry. There would also be more land for nature, complementing the improvements to farmland biodiversity enabled by the shift to biologically based farming.

IMPACTS ON FOOD PRODUCTION, DIETS AND SELF-SUFFICIENCY

If the UK were to switch to sustainable and regenerative farming methods:

— **Fruit, vegetables and pulses:** The production of these foods would double.

— **Grains:** Production would halve due to a phase out of chemical inputs and a move to diverse, mixed farming systems.

— **Pork, chicken and eggs:** Due to reductions in the amount of grain available for feed, intensive livestock production would end, resulting in a 75% decline in pork and chicken production and a 50% decline in eggs.

— **Dairy:** Production would fall by 20% as a result of the move to pasture-based systems.

— **Beef and lamb:** Production of beef would fall by around 8%, while lamb production would remain steady, reflecting the integral role of grazing livestock in regenerative farming systems.

Our modelling suggests that by aligning our diets to what the UK could sustainably produce and eating according to recommended intakes, we would be able to maintain or potentially even improve on current levels of self-sufficiency in terms of calories and key nutrients.

RECOMMENDATIONS

A nationwide transition to sustainable and regenerative food and farming systems will only be achievable with action from government and society at all levels, including:

— Changes in agricultural policy, including the redirection of subsidies and the application of the polluter pays principle.

— Support from the banking, financial and investment communities, such as preferential loans for those transitioning to regenerative farming systems.

— Major investment in decentralised food processing and distribution infrastructure.

— Investment in people and skills to accommodate the increased diversity in farm enterprises.

— Increased education and public awareness campaigns around food and farming, to enable greater understanding of these issues.

— Action by retailers and food companies to ensure fair pricing for producers and transparent labelling for consumers.

— Government intervention to protect against food poverty and ensure access to high-quality food for lower income groups.

— Measurement of the impacts of the agricultural transition from the farm up using an internationally harmonised framework, such as the Global Farm Metric.

This report, published in December 2022, is a summary of the full-length 'Feeding Britain from the Ground Up' report, published in June 2022 (available online). We have updated our modelling around dairy and beef production following feedback on the original version, however, our findings, conclusions and recommendations otherwise remain the same.

CHAPTER ONE

Introduction — the challenge to eat and farm sustainably

Chapter 1 — Introduction

In response to the environmental and human health problems caused by our current food system, this report seeks to explore a simple question: 'What should I eat to be healthy and sustainable?'

Around the world, growing numbers of people are facing extreme hunger. In the UK, the cost-of-living crisis, driven by high energy and food prices, is pushing millions into poverty. As a country, we face a food and energy insecurity emergency for the first time in a generation. The war in Ukraine, COVID-19 and an ever-increasing number of extreme weather events have supercharged this crisis, but the truth is, it was already on its way.

Over the last sixty years, many parts of the world have undergone a process of agricultural intensification. While this has allowed the world to grow ever greater quantities of food, it has also led to farming practices which have degraded soils, reduced biodiversity, contributed to climate change, polluted our landscapes and produced a huge amount of waste.

Industrial food production is also contributing to a global health crisis, fuelled by unhealthy diets. The increased production and consumption of ultra-processed foods, the overuse of antibiotics and the increased risk of zoonotic disease all threaten human health. At the same time, the high-tech nature of most farming systems has left us increasingly distanced from agriculture and, consequently, the story behind our food.

The scale of the problem could not be clearer, and successive statements arising from policy and climate gatherings have urged the need for change. Until now, however, calls for a global food system transition have fallen largely on deaf ears.

There are a number of reasons for this, but what's clear is that **the lack of consensus around what constitutes the most sustainable approach to food production** and the subsequent public confusion about what to eat to be part of the solution, must be addressed with urgency.

The debate around land sparing versus land sharing

Broadly speaking, two approaches to sustainable food production have been put forward, and while they are not entirely incompatible, they do represent very different visions for the future of farming.[1]

The first is based on the 'sustainable intensification' of agriculture — aiming to produce even higher yields of crops and livestock products than at present, whilst at the same time using fewer inputs (e.g. pesticides, fertilisers, fuel and labour), mainly through greater use of technology. In theory, this would allow food production to be focused on as small an area of land as possible, enabling some farmland to be freed up for nature conservation — otherwise known as 'land sparing'.

There are, however, a number of potential problems with the land sparing approach. While sparing land from agricultural use is necessary for the conservation of habitats and species that require minimal human intervention, some biodiversity actually benefits from nature-friendly farming practices. Furthermore, the intensive agriculture associated with this approach may have negative impacts on neighbouring habitats and there are serious issues around increased pesticide resistance, the need to move away from fossil fuels and energy-intensive inputs, and the degradation of arable land.

In recognition of these issues, others have argued for 'land sharing', where agroecological farming systems are designed to work *with* nature and without high levels of synthetic inputs. Biodiversity and the delivery of other ecosystem services such as the natural pollination of crops, carbon sequestration, clean air and water and flood management, are supported across the whole farmed landscape, and not just in areas 'spared' for conservation.

Despite the benefits associated with more nature-friendly farming, land sparing is generally given the most credence in debates around the future of agriculture. This is because the minimal use of synthetic inputs (and subsequent lower yields) associated with agroecological farming systems usually mean more land is required to produce the same amount of food, leaving less land for wild habitats.

However, this may not need to be the case. Our current food system is enormously wasteful: globally, around one-third of the food we produce is lost each year,[2] and 33% of the world's cropland is used to grow feed for livestock.[3] If this land were used to grow crops for direct human consumption, an additional 4 billion people could be fed.[4]

All of this, then, raises the question: **if we reduce the amount of food we waste and change our diets (in particular, by moving away from the consumption of intensively reared, grain-fed livestock products), could an agroecological approach provide us with enough food, without necessitating an increase in the area of farmland or the need for more imports?**

Previous research into a sustainable farming transition

The impact of a nation-wide transition to more nature-friendly methods of food production is something which a handful of previous studies have looked at. These serve as important precedents for this report.

In 1975, Kenneth Mellanby wrote Can Britain Feed Itself, a simple study modelling fairly conventional agricultural practices, published well ahead of its time.[5] This served as inspiration for Simon Fairlie's 2007 study, which looked at whether Britain could feed itself an omnivorous or vegan diet from conventional, organic and permaculture approaches to agriculture.[6] Both studies made the important finding that Britain could feed itself if meat consumption was reduced, yet neither study attracted wide public attention.

Two academic studies by Reading University have also attempted to model the impacts of a transition to agroecological farming practices in England and Wales; in 2009, the Soil Association commissioned a study into the impacts of conversion to organic production[7] and, more recently, Laurence Smith carried out more in-depth modelling.[8] Both studies found increased levels of production for vegetables, pulses and red meat, and significant declines in the production of cereals, oilseeds, pork, poultry and milk, but neither assumed any changes in diet or reductions in food waste in their calculations.

Most recently, French institute IDDRI completed a study for the Food Farming and Countryside Commission which modelled a UK-wide transition to agroecology.[9] Their food production findings were broadly similar to the aforementioned studies, but they also found that a shift to healthier diets would mean that the UK wouldn't have to import more food than it does at present. This means that agroecology could produce enough food, whilst at the same time meeting our climate and biodiversity goals.

Aims and scope of this report

Our intention with the Feeding Britain report is to build on this growing body of evidence and add to the conversation around what constitutes a sustainable approach to food production and diets in the UK.

To do this, we carried out a desk-based study that investigated the impacts on food production, land use and diets of a UK-wide transition to farming systems that work in harmony with nature. Our conclusions and recommendations look at what societal and governmental changes might be needed to enable such a profound transformation of our agricultural systems.

Of course, modelling a sustainable food system that meets the needs of humans, animals *and* the environment is complicated and involves difficult decisions and trade-offs, and so there were limitations to this exercise.

We have, however, attempted to be transparent in our approach, and have acknowledged the complexities of the issues as much as possible within both this summary report and the full-length version.

Our hope is that this report will help to inform the discussion about what we should eat, and how we can align our future diets more closely with the agricultural systems that are required to address climate change, restore nature, promote public health and improve national food security and resilience in line with planetary boundaries.

CASE STUDY

Shimpling Park Farm
Suffolk

John Pawsey is an organic farmer, growing arable crops and sheep on good quality agricultural land in the south-east of England.

Most of the farm is under a six-year rotation, growing a number of varieties of wheat, oats and spelt for milling, barley for malting and beans, which are mainly sold for livestock feed.

Small quantities of some novel and speciality crops, including chia, lentils, peas and vetches, are also produced, and John has been successfully trialling the production of organic oilseed rape. Since conversion to organic over 20 years ago, there have been major environmental improvements on the farm, with increases in the number of farmland birds and an ongoing rise in soil carbon levels that more than offsets the farm's emissions.

However, in 2014, it was decided that the fertility-building period needed to be extended, and to make this financially possible, sheep were introduced. This has been a huge success, delivering not just an increase in soil fertility and carbon levels, but also greater biodiversity and resilience.

Size: 649 hectares

- 550 hectares under cropping, under a six-year rotation consisting of:
  - two years of fertility-building leys, grazed by sheep
  - four years of cereal and bean cropping
- 25 hectares permanent pasture
- 20 hectares agroforestry
- 75 hectares under environmental conservation areas and woodland

Food output

- **Cereals:** 1000 tonnes for milling, 450 tonnes barley for malting
- **Beans:** 320 tonnes for livestock feed
- **Lamb:** 32 tonnes
- Plus small quantities of speciality crops — e.g., chia, lentils, peas and vetches

Number of employees

- On the farm, six full-time employees and a family for two months in the summer

CASE STUDY

Blaencamel Farm
Ceredigion

Blaencamel Farm is a 50-acre holding in West Wales run by Peter Segger and his partner Anne Evans. They have been certified organic vegetable, fruit and salad producers for 48 years.

The production system relies on a crop rotation based on 15 acres of field vegetables, 1.5 acres of multi-span tunnels (none of which are heated) and the rest is a mixture of grass/clover leys, green manures, woodland, hedges, a compost site and packing sheds. Key to the marketing of the farm's output are the tunnels which extend the growing season and provide year-round employment.

Peter and Anne estimate that providing Wales with the majority of its fresh produce requirements would necessitate around 200 Blaencamel-type units for specialist salad and vegetable production, complemented by a similar number of larger farms supplying the principal bulk crops, e.g. potatoes and carrots. Blaencamel produces over 50 individual crops annually, but the principal ones are fresh salad packs (approximately 20,000 retail packs), kale (around 16,000 retail packs), sprouts (10 tons) and potatoes (45 tons).

The system is not climate sensitive, and also has many environmental advantages. For instance, Peter and Anne's records show that the farm is carbon negative and has been for some time.

CHAPTER TWO

Defining and modelling regenerative agriculture

Chapter 2 — Defining and modelling

This chapter outlines the key characteristics of the farming systems modelled in this report, and explains how we estimated the impacts on land use, food production and self-sufficiency of a nationwide shift to regenerative farming in the UK.

As touched on in the previous chapter, there is a growing base of evidence to show that agroecological farming systems can help tackle the interrelated crises of climate change, biodiversity loss and poor public health. A number of existing, well-defined approaches to agroecological farming, including organic, biodynamic and regenerative, have been shown to deliver a wide range of benefits and have an important role to play.

However, as with any farming system, they have their limitations and there is the risk that promoting a single definition of regenerative farming could lead to siloed thinking and entrenched positions.

For these reasons, we decided that it would be preferable to model an approach to sustainable and regenerative farming defined by a set of overarching guiding principles and characteristics.

To maintain consistency, throughout the rest of the report we make use of the word regenerative, as a generic short-hand term to capture the principles laid out in this chapter.

Guiding principles

Core to our approach is food production that works *with* nature and its fundamental universal principles:

1. **The Farm as an Ecosystem —** Farms are managed in ways that encourage mutually beneficial interactions between plants, animals, the farmed landscape and its people.
2. **The Circular Economy —** Farming systems incorporate the law of return, reducing and reusing waste, recycling nutrients and building natural capital through regenerative practices.
3. **Health and Wellbeing —** Food production systems are designed to promote the health of soil, plants, animals, people and the environment.

Key characteristics

The way in which these principles are expressed in practice is diverse, depending on variations in soils, climate and topography, as well as individual, social and cultural factors. However, **all farms and food systems which operate according to these principles share a set of key characteristics:**

— **Minimising the use of non-renewable external inputs,** including chemical fertilisers and pesticides produced from non-renewable resources, due to their damaging impacts on climate change, biodiversity and human health.[1]

— **Using biological processes to build soil health, generate fertility and manage pests**, key to which is the use of crop rotations with a fertility-building phase of forage legumes, grasses and herbs.[2]

— **Rearing livestock in a high welfare, resource-efficient way**, through pasture-based systems integrated, where appropriate, with crop production.[3]

— **Reducing and recycling waste and by-products**, both before and after the farmgate.[4]

— **Minimising pollution** by reducing the use of synthetic inputs and fossil fuels and moving to well-managed pasture-based livestock systems.

— **Promoting diversity**, with mutually beneficial interactions encouraged between the different parts of the farm ecosystem — encompassing everything from the integration of crop and livestock production to the benefits which diverse rotations bring to crops, farm animals and wildlife.

— **Enhancing food quality** by producing a diverse range of crops and livestock products that contribute to healthy diets.

— **Delivering social and cultural benefits** through economic diversification and greater community engagement with the food system.[5]

The importance of grazing livestock in regenerative farming systems

The intensification of livestock production has had a number of negative impacts, including on animal welfare, biodiversity and climate change, and has also led to a rise in antimicrobial resistance, with potentially major implications for human health.[6] As a result, livestock have received a huge amount of negative attention over recent years.

What is not widely understood, however, is that **livestock, when reared in an appropriate fashion, play a vital role within regenerative food systems**[7] for a number of reasons:

- In crop production systems which don't rely on synthetic fertilisers and pesticides, the grass and legume phases of the rotation play an essential role in rebuilding soil fertility and breaking pest, weed and disease cycles.[8] Producing food — and therefore income — from this phase of the rotation, generally requires grazing by livestock.
- Livestock can directly benefit soil health through their grazing and trampling of vegetation and via the manure they produce, helping to minimise or eliminate the need for chemical fertilisers.
- They can help to suppress crop pests, weeds and diseases through their grazing, minimising or eliminating the need for chemical pesticides.
- Livestock are able to consume feeds which humans can't or don't want to eat (such as grass, crop by-products and food waste), and then 'upcycle' these into nutrient-dense foods. This allows us to produce food from the extensive areas of agricultural land which aren't suitable for crop production, reduces the pressure on croplands and represents a key livelihood for many rural communities.
- Many of the UK's most important habitats and species of wildlife greatly benefit from, or even rely upon, well-managed livestock grazing.[9]

Fulfilling this beneficial role means rearing livestock in ways that are very different to the intensive systems which supply so much of our meat, milk and eggs today. Lower stocking densities, minimal use of human edible feeds and antimicrobials, outdoor-based systems with a focus on supporting biodiversity and the highest standards of animal welfare, are all essential to delivering the benefits listed above.

Of course, a nation-wide transition to this approach to livestock production would have major consequences for the amount of meat, milk and eggs that we would be able to produce (and therefore consume) and would also have important implications for greenhouse gas emissions. For more information on these issues, see Chapter 3.

Methodology

We took these principles and characteristics and used them to design the farming systems modelled in this report. In doing so, it was necessary to make assumptions around various factors, including the allocation of resources to different crops and livestock, the area of land used for non-agricultural purposes, and levels of productivity.

It's crucial to keep in mind, therefore, that the assumptions and findings outlined in this report represent just one vision of what a transition to regenerative farming might mean for the UK. To make it easier to understand our approach, we have pulled out several key assumptions, which are expanded on later in the report.

Key assumptions

DIETS

This report is based on the proposition that **enabling the transition to more regenerative farming practices in the UK will require citizens to more closely align their diets to what we can sustainably produce.** For this reason, we assume that government and others will put the conditions in place to make this change possible.

Of course, individual food choices are influenced by a variety of factors other than issues of sustainability, and so the question of dietary change is fraught with difficulty. However, it is widely accepted that changing what we eat is urgently needed for both planetary and human health.

FOOD SECURITY

Gaining a clear understanding of the UK's capacity to achieve a reasonable degree of food security under regenerative farming conditions is crucial, given growing political and climatic instability and concern around the UK's reliance on imported food.

The desire to understand whether the UK could feed itself following a transition to regenerative farming practices influenced our modelling in terms of land and feed allocation. It also influenced our decision to **not assume the import of any animal feeds** in our study, so that the UK's true level of self-sufficiency could be assessed, as well as our decision to **assume no use of agricultural land for bioenergy crops.**

CHANGES IN FARMING PRACTICE AND LAND USE

A transition to regenerative farming systems would require major changes to farming practice, which led us to make the following assumptions:

- **Fertility:** While biologically based farming systems don't necessarily require the elimination of all chemical inputs, for the purposes of this study we assumed no use of synthetic fertilisers. Instead, fertility is generated through diverse crop rotations, animal manure and compost, based on current organic practice.
- **Pest-control:** Similarly, we assumed no use of chemical pesticides, with pest control achieved through the use of well-designed rotations, resilient crop varieties and the provision of on-farm habitats for pest predators.

— **Pasture-based systems of livestock production:** We have assumed that all livestock would be reared in pasture-based systems, with animals kept at lower densities than is often the case at present and grazed in a way that delivers benefits for biodiversity and supports high levels of animal welfare.

— **Livestock feed:** The feeding of vast quantities of cereals to livestock results in a major loss of calories and nutrients from the food system.[10] This, along with the predicted reduction in arable production, led us to assume that arable crops would be used mainly for human consumption. We have also assumed that monogastric livestock (poultry and pigs) would consume a greater quantity of human inedible feeds than today, including forage, and that 40% of food currently wasted beyond the farmgate would be heat-treated and fed to pigs (as well as a small amount to poultry).[11] Finally, we assumed the elimination of all imported soya bean meal, due to the overseas habitat loss associated with its production.[12]

— **Agroforestry:** We assumed that 10% of all farmland would be used for agroforestry, because of the wide range of farm and environmental benefits it can deliver.[13] On good to moderate quality land we assumed a model based on widely-spaced lines of trees, many of which would yield fruit, with arable and/or grass cropping between each row.[14] On land not suitable for crop or hay/silage production, we assumed a higher density of trees that would instead be used for timber and other non-food purposes.[15]

— **Urban agriculture:** To help increase the UK's production of fruit and vegetables, we assumed that around 50% of allotment space, 20% of the cultivated area in gardens and the existing stock of urban fruit trees, would supply us with produce.[16]

FARM PRODUCTIVITY

The UK-wide adoption of regenerative farming systems will inevitably reduce the yields per hectare of most crop and livestock products (though some crops would see less of a decline). We have based our modelling on existing organic yields, but assumed a 20% increase for crops, in reflection of the potential that exists to increase organic yields through breeding programmes and other innovative practices, as expanded upon later in this chapter.

Until now, farm productivity has mainly been assessed on the weight of food produced per area of land, without taking into account nutrient density or the number of people this food would actually feed. However, there is a strong argument that we should move from assessing yields per acre, to assessing nutrition per acre, as this is a more meaningful measure of productivity.[17]

Therefore, t**he concept of nutrition per acre very much informed our assumptions around the prioritisation of human food production on arable land** (rather than feed), as well as around the allocation of land to a wide diversity of crops.

WASTE

Mindful of the yield reductions that will result from the application of the recommendations of this report, a key assumption factored into our calculations is a reduction of food waste. **This report assumes a 50% reduction in food waste beyond the farmgate, in line with the UK's Courtauld Commitment**.[18] We also assume that a portion of both food and crop waste would be fed to livestock, alongside crop by-products and whey.

Farming systems would also become less wasteful through a move from grain-based livestock systems (which represent an inefficient use of crops that could be eaten by humans) to pasture-based ones, with arable land being primarily used for growing crops directly for human consumption.[19]

INNOVATION AND TECHNOLOGY

Some people conflate a biological approach to food production with a rejection of **new technologies and practices**. However, these **will have an important role to play in improving the sustainability of regenerative farming systems**.

Novel and alternative sources of feed, rotational grazing systems, intercropping and breeding programmes for crop varieties better suited to low-input farming systems are examples of agricultural innovations which we've either modelled or assumed the use of. However, there are many other new and innovative practices and technologies that we haven't taken into account, which will likely have an important role to play in the future.

INFRASTRUCTURE AND DEMAND

A key assumption of this report is that to enable the transition to regenerative farming systems, the necessary increases in skills, workforce and infrastructure would be achieved, alongside changes in consumer behaviour and government policy. Without these, transformative and long-lasting change would not be possible.

CLIMATE CHANGE

It wasn't within the scope of this report to measure the climate impacts of the changes in the farming practices that we modelled — this is something which IDDRI's recent report has done, showing that **agroecology could deliver major reductions in emissions and increases in carbon sequestration**.[20] However, the need to tackle climate change featured heavily in our assumptions.

We modelled a number of practices which would likely have a positive impact on carbon sequestration and greenhouse gas emissions, including the incorporation of temporary grasslands in arable areas, a significant increase in the area under agroforestry, an increase in the length and better management of hedgerows, better grazing management, lower stocking densities and the end of nitrogen fertiliser (this is expanded upon in Chapter 3).

We also assumed that 0.9 million ha of grade 4 and 5 land would be used for woodland creation, in line with the recommendations of the UK Climate Change Committee. This would deliver major benefits for the climate, provided it is delivered in a sustainable manner.

NATURE

We didn't attempt to measure the impacts on biodiversity arising from the modelled changes in farming practice. However, **as with the need to tackle climate change, biodiversity restoration is an intended outcome of the regenerative farming practices featured in this report**. Our assumptions around agroforestry and hedgerow cover, the use of rotational grazing systems, a de-intensification of livestock production, an increased diversity of crops and the elimination of synthetic fertilisers and pesticides would all have significant benefits for nature, as is outlined in Chapter 3.

In recognition of the fact that certain habitats and species benefit from no or very low levels of agricultural activity,[21] **we have also assumed the removal of 1 million ha of grade 5 land from food production, to be used for woodland expansion and 'rewilding', as well as 10% of all croppable land**.

Step 1: Divide the UK's farmland area according to variations in agricultural capability

The UK's agricultural area, covering more than 70% of the country,[22] is hugely diverse. To capture this variation in agricultural capability across each of the four nations, we used data from two land classification systems: the Agricultural Land Classification (ALC) system, used in England, Wales and Northern Ireland;[23] and the Land Capability for Agriculture (LCA) system, used in Scotland.[24]

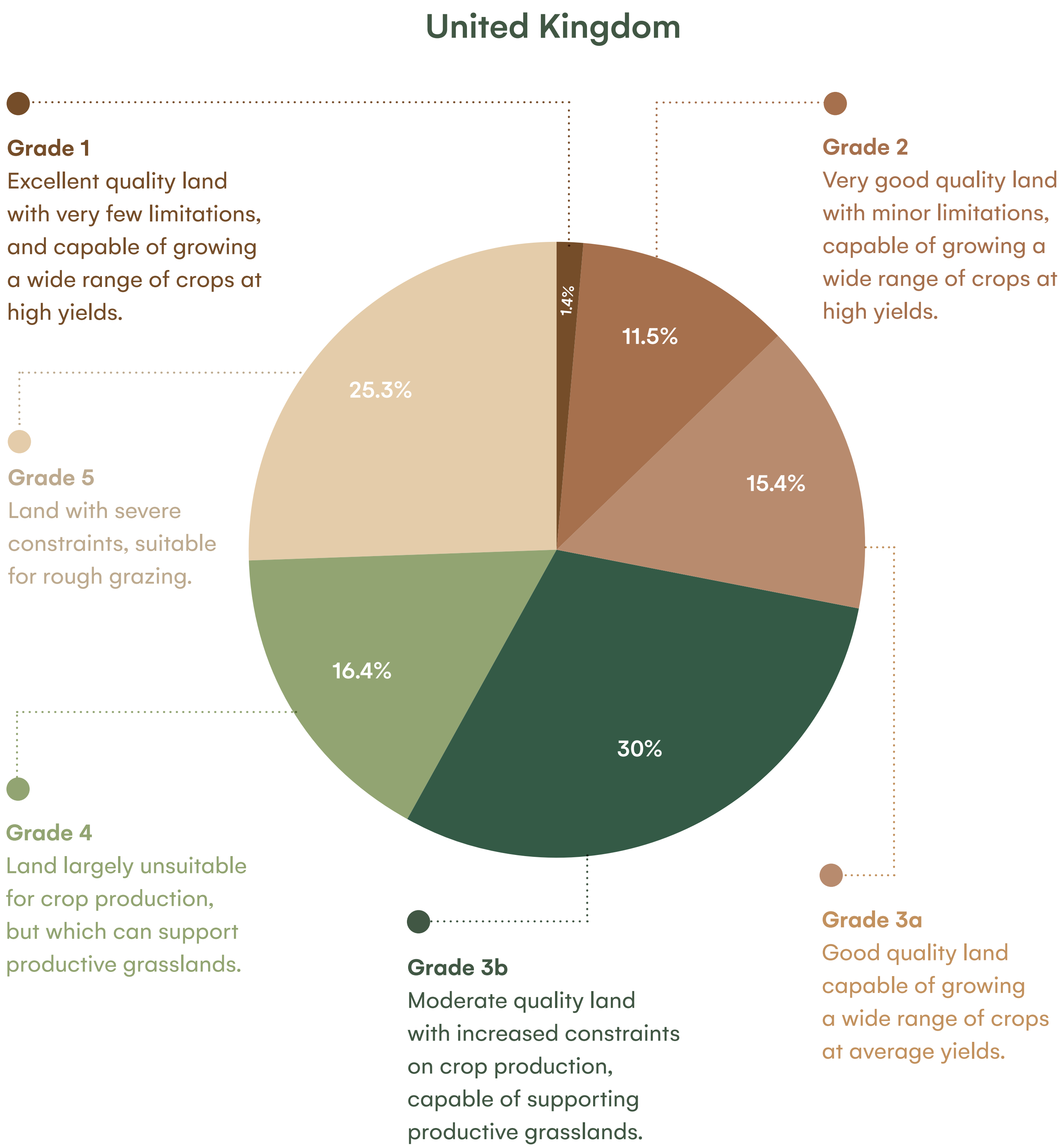
Both systems use soil, climate and topographical information to determine agricultural capability across the home nations. Land is categorised into 'grades' or 'classes', ranging from excellent quality Grade 1 (or LCA class 1) land to very poor Grade 5 land (broadly corresponding with LCA classes 6.1–7).

Figures 2.1 and 2.2 illustrate the very significant variations in the quality of agricultural land across the UK, which in turn determine the types and quantities of food that can be produced.

FIGURE 2.1: HOW THE QUALITY OF AGRICULTURAL LAND VARIES ACROSS THE UK*

* Figure 2.1 is a schematic representation of official ALC and LCA maps, and so is not intended to show the exact distribution of grades

FIGURE 2.2: THE CAPABILITY OF AGRICULTURAL LAND IN THE UK*



*ALC and LCA breakdowns were provided by Natural England, the Welsh Government, the James Hutton Institute and DAERA

Step 2: Design regenerative farming systems for each land type

Having created a land base for this study, our next step was to design a set of regenerative farming systems compatible with the productive capacity of each grade of land.

To reflect the variations in productive capacity, we devised four primary production systems with a set of variants. **The systems and livestock enterprises outlined below should be treated as guides or templates**. Many farms contain a mix of different grades of land, and so individual farms might support a combination of the different systems and enterprises modelled here.

Similarly, while we have had to be prescriptive in the proportion of land used for different crops and livestock within each system, these are average figures (taken largely from the organic literature) applied across all the land to which that system might apply. Individual farmers adopting one of these systems might, therefore, have a mix of crop and livestock enterprises that differs from the averages described in this study.

Livestock enterprises — assumptions and descriptions

With regard to livestock in our modelling, the following enterprises are included:

Dairy: We assumed robust breeds of dairy cattle, with any calves not selected for milking, instead reared for meat. In our modelling, a stocking rate of 1.5 animals per hectare is assumed, with 1,000 kilos of supplementary feed (made up of UK-grown cereals, pulses and crop by-products) also given to each cow per year, allowing for an annual milk yield of around 6,000 litres per cow.

Beef and sheep: On grade 1, 2, 3 and 4 land we assumed a beef cattle and sheep enterprise with animals reared in a pasture-based system at a stocking density of 1.1 livestock units per hectare and with no use of supplementary feed.

Hill beef and sheep: On grade 5 land, we have assumed the use of beef and sheep enterprises using hardy breeds kept at low stocking densities (0.1 livestock units per hectare). Most calves and lambs are sold at the end of their first summer to be finished on lower land.

Pigs: Pigs are reared in free-range outdoor systems where they are able to express their natural behaviours and can obtain a significant percentage of food from foraging. They are also fed a mix of heat-treated food waste, cereals, pulses and by-products.

Poultry: Laying hens and table poultry are also assumed to be reared in outdoor systems, allowing them to forage. Their main feed consists of a mix of cereals, pulses and non-human edible arable by-products.

1. Farming on grades 1, 2 and 3a — The best quality agricultural land

Predominant farming system: Mixed arable and livestock

Typical rotation: 3–4 years cropping, 3 years fertility building
Possible enterprises: arable cropping; field vegetables; dairy; beef and sheep; pigs; laying hens; table poultry

This diverse production system occupies much of the UK's most fertile land in our model, providing a wide range of staple foods, including grains, pulses, vegetables, fruits and livestock products.

Alternative 1: Stockless cropping

Typical rotation: 4 years cropping, 2 years fertility building
Possible enterprises: arable cropping; field vegetables

This system would produce a wide range of crops for human consumption but without the integration of livestock; instead using shorter, more frequent fertility-building leys and green manures.

Alternative 2: Specialist horticulture (vegetables)

Typical rotation: 3–4 years cropping, 2–3 years fertility building
Possible enterprises: field vegetables; protected vegetables; livestock enterprises*; cereals* (*applicable where this system is operated at larger scales)

Some of the land in this category would be allocated to a more specialised and biologically intensive approach to vegetable production. A wide variety of vegetables would be grown at both small and large scales, always with the use of short-term fertility-building leys.

Alternative 3: Specialist horticulture (fruit)

Possible enterprises: top fruit; soft fruit; laying hens*; table poultry* (*applicable where top fruit, but not soft fruit, is grown)

As with the specialist vegetable system, we assumed that a greater area of land than at present would be used for growing a variety of orchard and soft fruits.

2. Farming on grade 3b — Land with increased constraints on crop production

Predominant farming system: Mixed livestock and arable

Typical rotation: 50% of productive land under permanent pasture; on other 50%, 2–3 years cropping, 6–7 years fertility building
Possible enterprises: dairy; beef and sheep; arable cropping; field vegetables; pigs; laying hens; table poultry

We assumed that on much of the UK's less fertile croppable land, the balance of arable and livestock production would shift. Grazing livestock form the main focus of food production in this system, but a variety of crops including cereals, pulses and vegetables would still be grown.

To enable greater regional diversity in food production and the decentralisation of food distribution, our modelling also included a small allocation of grade 3b land to specialist horticulture enterprises.

3. Farming on grade 4 — Land largely unsuitable for crop production but which can support productive grasslands

Predominant farming system: Grazing livestock

Possible enterprises: beef and sheep; dairy

On grade 4 land, greater environmental constraints largely exclude arable cropping. However, this land is generally capable of supporting good levels of grass growth, and so can be used for productive systems of grazing livestock. The main enterprise assumed in this system is the rearing of beef cattle and sheep, though we also allocated some dairy production.

Because of the greater environmental constraints, we assumed lower stocking densities than on better grades of land. However, with holistic grazing techniques and the reseeding of pastures with nutritious species of forage plants, good levels of pasture productivity can be maintained across most of this land.

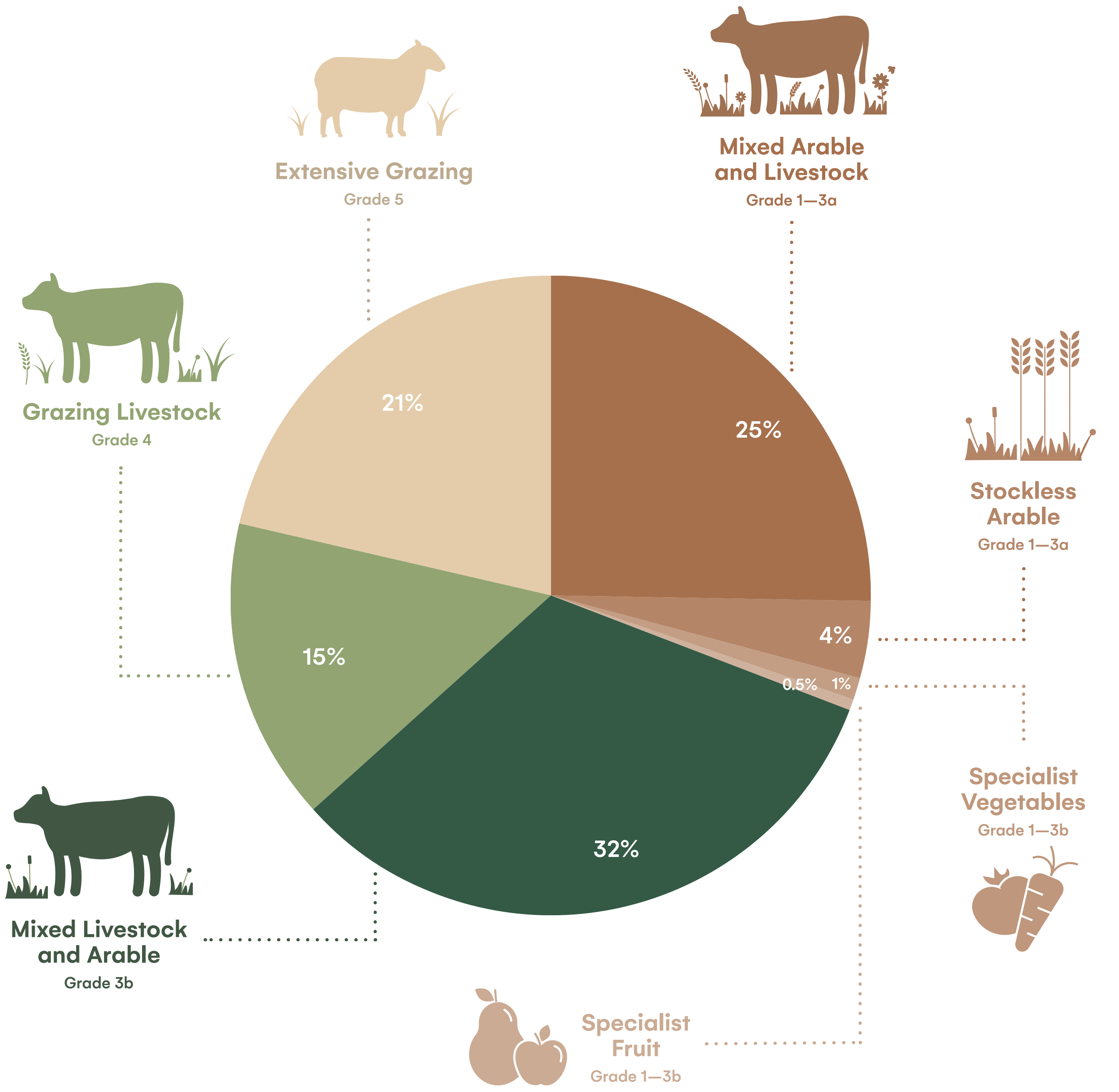
4. Farming on grade 5 — Land limited to extensive, rough grazing

Predominant farming system: Extensive grazing

Possible enterprises: hill beef and sheep

On the extensive areas of native grass and moorlands which cover much of the UK's uplands, we modelled a system where hardy breeds of cattle and sheep would be reared at low densities, in line with conservation grazing recommendations. Some improved pasture is also allocated to this system to allow for winter feed production and higher quality grazing at key stages of the animals' breeding cycle.

FIGURE 2.3: HOW THE UK'S AGRICULTURAL LAND WAS ALLOCATED TO DIFFERENT FARMING SYSTEMS



Step 3: Calculate food productivity of a sustainably farmed UK

Having allocated the UK's agricultural area to the farming systems modelled in this study (as shown in Figure 2.3), the next step was to calculate how much food these systems, and the nation as a whole, would produce.

As part of our decision to model biologically based farming systems, we decided to use data from the organic sector. This is because it is the closest system to the approach modelled in this study for which there is also plenty of published data on productivity.

Lower yields are almost inevitable in the kinds of regenerative farming systems modelled in this study. However, there is thought to be considerable potential to increase these through a number of strategies:[25]

— Intercropping, where two or more different crops are grown alongside each other on the same piece of land, has been shown to increase the total yield of food per hectare. One review of intercropping trials found that total yield per hectare increased by 22% on average.[26]

— Greatly increasing the amount of research into the development of crop breeds suitable for agroecological systems is another key strategy, given that almost all commercial breeding work to date has been focused on conventional, high input systems.[27]

— Productivity could also be increased through the recycling of nutrients from sewage and wastewater, which currently represent a major source of pollution.[28]

Taking these strategies into account, we have assumed a 20% increase in current organic crop yields.

Step 4: Assess the impact on individual diets and nutrition

The final step in our methodology was to investigate what impact any changes in food production might have on our individual diets and national self-sufficiency.

First, we calculated **the amount of UK–produced food that would be available for human consumption** by adjusting the production figures to account for the amount that would be 'lost' through processing (e.g. cheesemaking and milling) and used for other purposes such as livestock feed.

We then divided the total amount of UK–produced food available for human consumption by the total projected population of the UK in 10 years' time (70 million),[29] to reflect the fact that we will not be able to transition to regenerative farming systems overnight. This then provided us with figures on **how much food per person per day would be available from UK production**. To enable a comparison with the present day, we also carried out these calculations for current UK production.

Next, we assessed **what contribution regenerative farming systems would make towards our daily nutritional needs**. To do this, we calculated how many calories and how much protein, fat and carbohydrates would be available for consumption, per person, from sustainable UK production, using official data on the nutrient composition of different foods.[30] We then compared this against the European Food Safety Authority's (EFSA) recommended intake of calories, protein, fat and carbohydrates for an average European adult.[31]

We also calculated how many calories and macronutrients are available for consumption from current UK production. These figures, along with a calculation of the current total demand for calories and macronutrients,[32] allowed us to compare **how the UK's self–sufficiency would change** following the transition to regenerative farming systems, assuming a future change in diet to EFSA's recommended levels of intake.

CASE STUDY

Balcaskie Estate
Fife

Situated in the East Neuk of Fife, Balcaskie Estate is an organic mixed livestock and arable farm.

Seven years ago, in an attempt to improve their financial and environmental sustainability, they converted the farm to organic. Today, most of the farm is under pasture, grazed by cattle and sheep, but 200 hectares is cropped under a rotation, with five years of diverse, fertility-building herbal leys grazed by livestock, followed by two years of cereal and bean production, grown for human consumption.

Since conversion, the farm has moved to a 100% pasture-fed approach, using native breeds of cattle and sheep and mob grazing systems, which has eliminated the need for bought-in feeds, significantly reduced costs and improved biodiversity. The farm has also seen an improvement in soil health, increased employment, and a reduction in energy use, with around 50% of energy now provided from heat and solar produced on-farm.

Size: 1300 hectares

- 200 hectares under cropping, under a seven-year rotation consisting of:
  - five years of fertility-building leys, grazed by beef cattle and sheep
  - two years of cereal and bean cropping
- 1000 hectares of grassland

Food output

- **Beef:** 80 tonnes
- **Lamb:** 20 tonnes
- **Cereals and pulses:** 1000 tonnes

Number of employees

- Eight

CASE STUDY

Cannerheugh Farm
Cumbria

Situated above the Eden Valley in Cumbria, Cannerheugh Farm, run by Nic and Paul Renison, produces 100% pasture-fed beef, as well as pastured eggs, chicken and pork.

Until 2013, Cannerheugh was managed in a conventional fashion, but in an attempt to improve profitability, Nic and Paul decided to move to a rotational grazing system. This proved successful, but it also led to the realisation that a regenerative approach could deliver a wide range of other benefits too, including for biodiversity and human and animal welfare.

Since then, the farm has steadily moved away from what was effectively a monoculture of sheep, towards more cattle, as Nic and Paul have found them to work much better in a rotational grazing system. This shift, alongside a focus on maintaining good vegetation cover after grazing, long rest periods and the use of species-rich herbal leys, has enabled the farm to end its reliance on bought-in fertilisers, feed and pesticides, which carried a major financial and environmental cost.

Nic and Paul have also integrated many more trees onto the farm, providing shade and shelter for their livestock as well as being an ideal setting for a small glamping enterprise. In time, they hope the trees will also provide fruit, tree fodder for their animals and, longer term, wood chip for bedding.

Size: 360 acres

- 60 acres improved pasture
- 140 acres permanent pasture
- 100 acres rough grazing
- 50 acres woodland

Food output

- **Beef:** 25 tonnes
- **Pork:** 1.5 tonnes
- **Poultry:** 1.25 tonnes
- **Eggs:** 110,000

Number of employees

- Two (Nic and Paul)

CHAPTER THREE

Results — How land use and food production would change

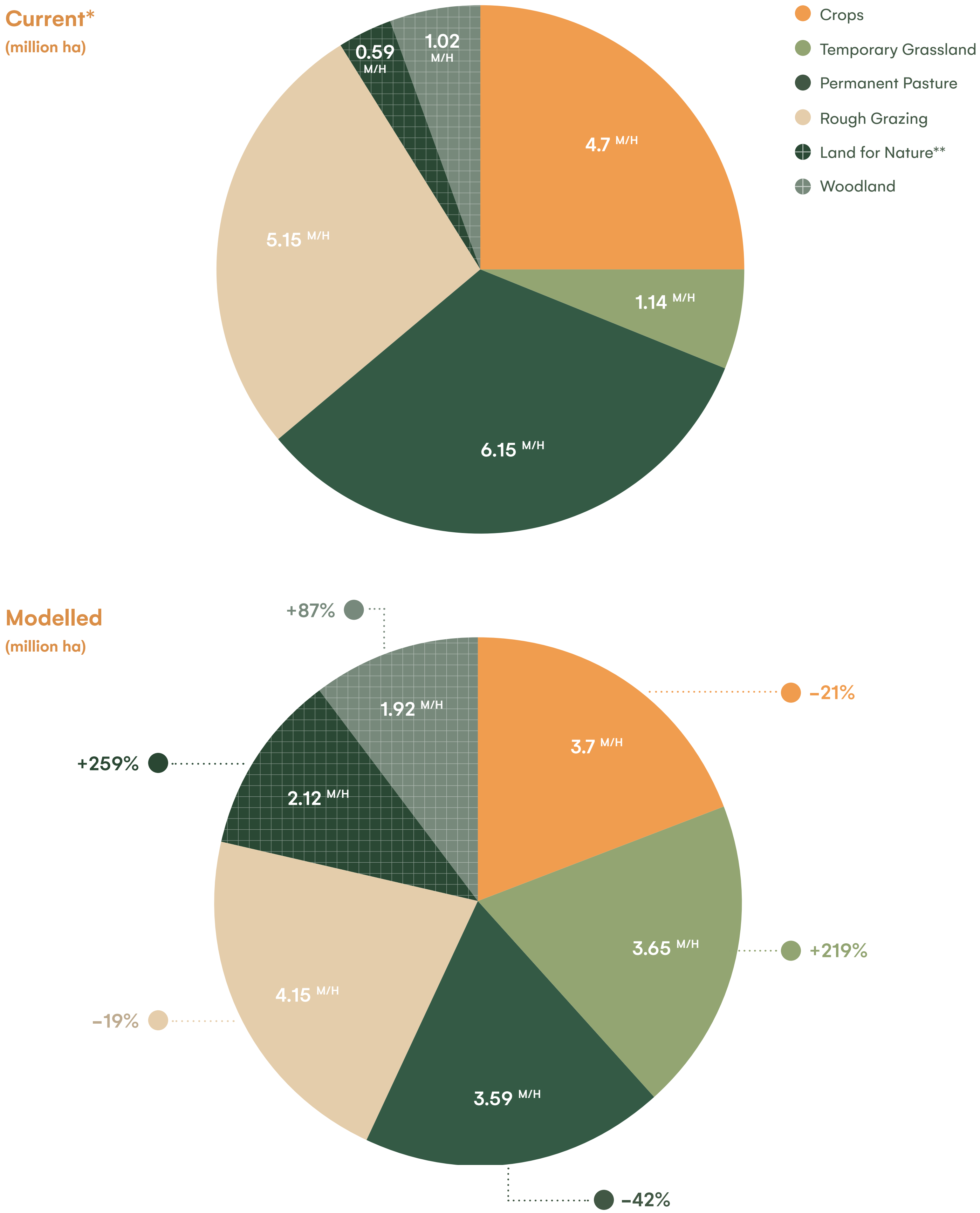
Chapter 3 — Results

A UK-wide transition to regenerative farming systems would have significant impacts on land use and food production, marking the end of a seventy-year chapter in agricultural history, during which, farming has become increasingly specialised. Instead, this siloed approach would give way to a diversity of integrated livestock and crop production systems on mixed farms across the UK. This chapter sets out the changes we modelled and the resulting impacts on food production.

Impacts on land use

The transition to regenerative farming would transform the farmed landscape, as is shown in Figure 3.1. The general move to mixed farming would result in the reintroduction of grassland and grazing livestock in arable areas and cropping in some regions currently dominated by grassland. Across the nation, we have modelled a significant increase in tree cover and land used for nature.

FIGURE 3.1: CHANGES IN UK LAND USE FOLLOWING THE TRANSITION TO REGENERATIVE FARMING



*Defra, 2019
**For current, includes uncropped arable and other non-agricultural land

WOODLAND AND LAND FOR NATURE

In our modelling, **woodland cover would increase by close to a million hectares (+28%)**, from roughly 13% of the country to 17% — in line with the recommendations of the Climate Change Committee.[1] The farmed landscape would also contain many more trees through the introduction of agroforestry systems across 10% of the UK's farmed area, resulting in a much greater integration of trees, crops and livestock than at present.

Land for nature and ecosystem services would also increase by approximately 1.5 million hectares. Around two-thirds of this would consist of upland areas removed from agricultural production, while the other third would be attributed to the improved integration of biodiversity-enhancing features (such as hedges, wildflower meadows, beetle banks, wetlands and woods) into croppable land.

These changes would see the total area of agricultural land in the UK fall from 72% (17.5 million hectares) of the total land area of the UK to 62% (16.1 million hectares).

CROPLAND

Although the total area of arable land (i.e. land used for cropping and temporary grasslands) would increase in our modelling, the area put under crops in any one year would decline by 21%. This is because temporary grasslands would be a much greater feature of arable areas than at present, due to their critical importance in building fertility and breaking the lifecycles of pests, weeds and diseases.

Informed by the need to add more diversity to our farming systems, and to grow more foods beneficial for human health, we also modelled major changes in the balance of crops grown. **The area under pulses would increase by 131%**, reflecting the importance of peas and beans as nitrogen-fixing break crops and valuable sources of protein for humans and livestock.[2] **The area of agricultural land under fruit and vegetable production would also increase, by 52%**, to reflect these crops' importance for human health.

Vegetables would be grown in specialist production systems, as well as in mixed farming systems and, in the case of top fruit (such as apples, pears, plums and cherries), from a portion of the area under agroforestry.

For other crops, however, we have modelled a decline. **The area used to grow cereals would fall by 25%.** This decline is mainly explained by the major increase in the area of temporary grassland on arable land and the need to grow a greater diversity of crops within regenerative systems.

The area under oilseeds and sugar beet would see even greater declines, with a 65% and 88% reduction respectively. We have decided to limit the amount of land used for growing these crops due to the prioritisation in our model of what we feel are more important crops, the need to reduce sugar in diets (relevant to sugar beet), the damage to soil health often associated with sugar beet production,[3] and the fact that both crops are heavily reliant on pesticides.[4] It is worth noting, however, that trials into organic oilseed rape production in the UK are having success, so in the future a greater area of land might be given over to this crop than we assume here.[5]

GRASSLAND

In our modelling, there would be major changes to the area under grassland. **The area devoted to permanent pasture would decline from 6.2 to 3.6 million hectares (–31%)** due to an increase in tree cover, the conversion of some improved grassland to rough grazing, and the conversion of some permanent pasture to land that would grow arable crops within a long-term, grass-dominated rotation. Our decision to increase woodland cover and allocate 1 million hectares of grade 5 land for nature restoration, would also see **the area under rough grazing decline by 19%.**

The area under temporary grasslands, meanwhile, would increase by 219%, due to the critical importance of such land in the regenerative farming systems modelled in this report.

Potential impacts on biodiversity and climate change

Regenerative, nature-friendly farming systems are characterised by the minimal use of chemical inputs, and diverse, complex landscapes which contain an abundance of semi-natural habitats.[6] For this reason, **the approach to farming modelled in this report would almost certainly result in a more biodiverse landscape than today**, given the following assumptions:

- The elimination of pesticides and chemical fertilisers[7]
- A wide diversity of crops grown in rotation[8]
- The use of a diversity of forage legumes and other species in temporary grassland[9]
- The allocation of 10% of the nation's croppable area to on-farm natural habitats[10]
- A major increase in hedgerow and agroforestry cover[11]
- The transition of around 2 million hectares of land, mainly from agricultural use, to woodland and rewilding[12]
- Appropriate stocking densities of sheep and cattle, grazed in ways that benefit biodiversity[13]

The land use and farming practices modelled in this study would also likely deliver major increases in carbon sequestration and reductions in greenhouse gas emissions through:

- A significant increase in the area of arable land under temporary grasslands[14]
- Major increases in woodland, agroforestry and hedgerow cover[15]
- Increased land for nature and rewilding[16]
- Changes in grazing management[17]
- Elimination of nitrogen fertiliser use[18]
- Phasing out of intensive livestock production and the resulting fall in livestock numbers
- Elimination of imported soya bean meal[19]

Set against these carbon benefits, would be the loss of soil carbon due to the modelled conversion of some permanent pasture to arable land — a tradeoff which would need to be weighed against the benefits for food system diversity and biodiversity that an increase in arable area would provide.[20]

Because sheep and cattle numbers are maintained at roughly current levels in our model, this may present a problem in terms of methane emissions. However, whilst we will need to reduce methane emissions from livestock to stay under 1.5°C of warming, methane's short-lived nature means that we will not have to eliminate its emissions entirely, unlike carbon dioxide emissions, which must be reduced to net-zero as soon as possible due to their persistence in the atmosphere.[21]

There are various strategies being developed which may allow us to achieve the necessary reductions in methane emissions by 2050, without major cuts to grazing livestock numbers. These include reducing the size of breeding cows and improvements to herd health,[22] and selective breeding for low methane emissions, which appears to offer major potential.[23]

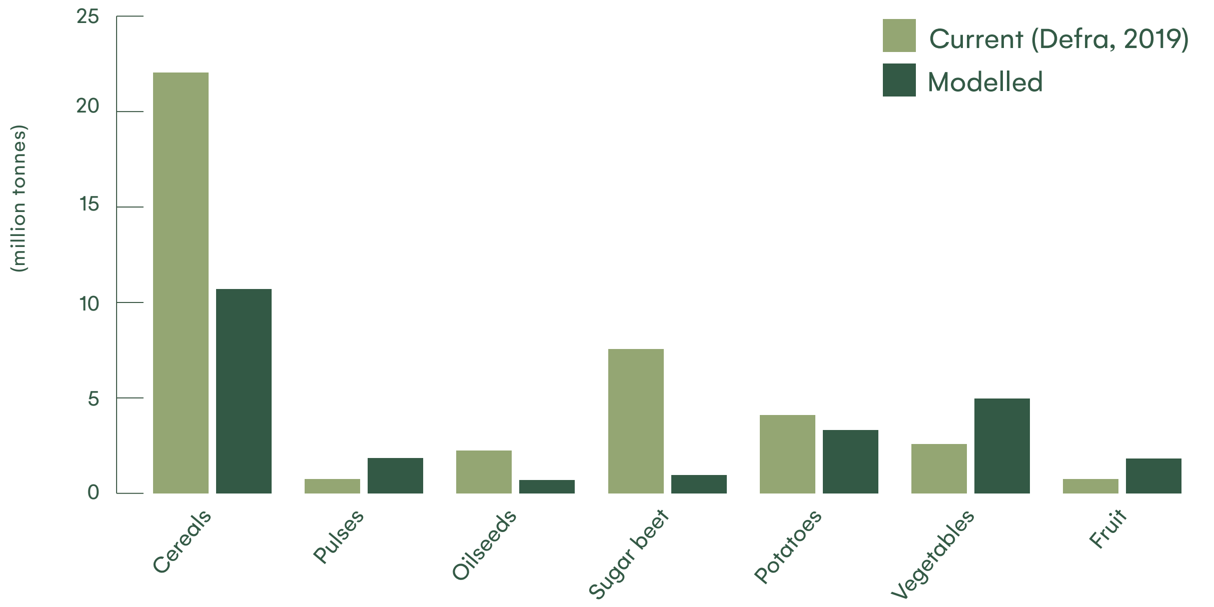
It is outside the scope of this report to say what the net climate impact of these changes would be. However, **a recent study carried out by the French research institute IDDRI estimated that a UK-wide transition to agroecology would result in a 38% fall in agricultural emissions.**[24] While their modelling assumptions differ somewhat from ours (for instance, a greater reduction in ruminant numbers) their findings do point towards the kind of carbon gains which might be expected from the approach modelled in this study.

Impacts on food production

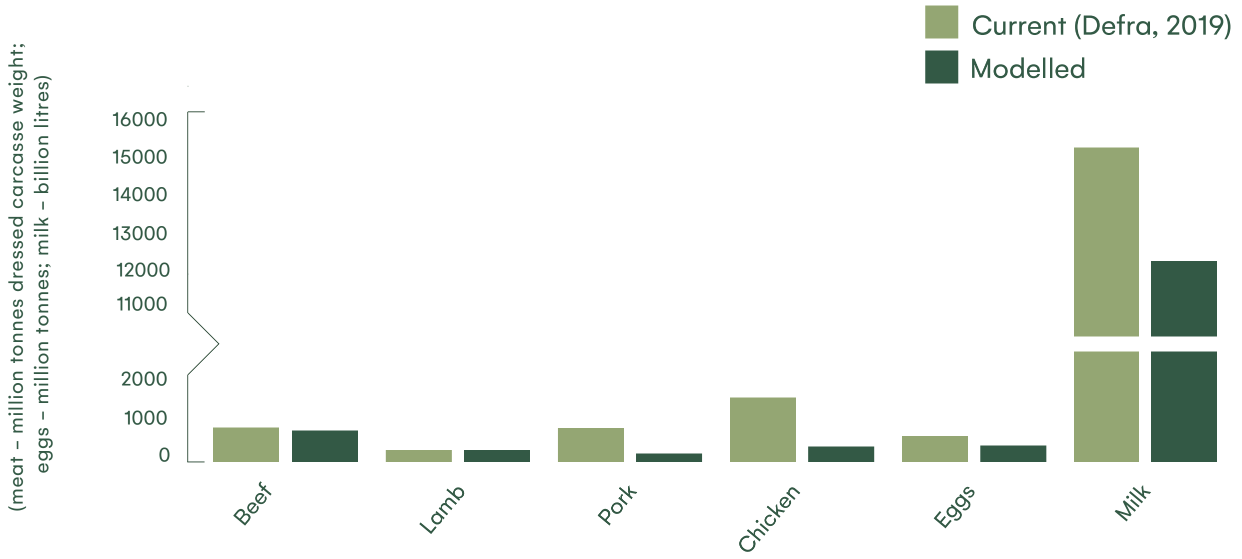
As a result of the land use changes and regenerative farming practices which we modelled, there would also be major changes to the production of food in the UK, as can be seen in Figure 3.2. Grain output would fall significantly, resulting in major reductions in pork, chicken and egg production, and to a lesser extent dairy. Conversely, fruit, vegetable and pulse production would increase, whilst beef production would fall by a relatively small amount (and lamb production would remain stable) due to the central role of grazing livestock in regenerative systems.

FIGURE 3.2: HOW FOOD PRODUCTION WOULD CHANGE FOLLOWING A TRANSITION TO REGENERATIVE FARMING

Current vs Modelled Production: Crops



Current vs Modelled Production: Livestock



CROPS

Total cereal production would fall by around 50% due to the smaller area of land allocated to growing cereals and the lower yields associated with the elimination of synthetic inputs. Wheat and barley production would fall by over two-thirds, only partially offset by a significant increase in the production of oats and rye, which are well-suited to low input systems.

Oilseed rape and sugar beet production would also fall significantly, by close to 70% and 90% respectively, for the reasons outlined earlier in this chapter.

With less land used to grow cereals, sugar beet and oilseed rape, **we were able to allocate more land to healthy food crops, resulting in a doubling of fruit, vegetable and pulse production in our model.** It's worth noting that a third of total production would come from urban areas, based on the assumption set out in Chapter 2 that around half of the UK's available urban allotment area, 20% of cultivated garden space and all current urban fruit trees would be used and harvested for fruit and vegetables.

A wide range of vegetables is assumed in the model, with the bulk of production being brassicas, root vegetables, alliums, squashes and salads. Tomatoes, peppers and other vegetables grown in polytunnels and greenhouses would also be produced in our modelling, extending the season for producers and consumers. **Potato production, however, would fall by around 20% due to a reduction in yields resulting from the removal of nitrogen fertiliser and fungicides.**

MEAT, MILK AND EGGS

One of the most notable results from our modelling is the **major decline (around 75%) in the production of pork and chicken — a reduction that is partly due to the elimination of imported soya meal in our modelling, but primarily explained by the reduction in cereal production.**

Cereals are a key ingredient in pig and poultry feed, and the major increase in cereal production over the past 70 years has been fundamental to the dramatic rise in the production and consumption of chicken in particular. The modelled reduction in cereal production would reverse this trend, as there would no longer be enough cereals available to sustain current pig and poultry numbers whilst also maintaining the necessary supply of grains for human consumption.

For this reason, **the amount of cereals fed to livestock would fall dramatically**, from about 50% of UK-grown cereals at present[25] to less than 20%. This would increase the overall efficiency of the food system, since feeding large quantities of cereals to livestock results in a major loss of calories and nutrients.

Egg production would decline for the same reasons as pork and poultry production, but at a lower level due to the prioritisation of eggs over poultry meat. Not only is it more efficient to produce eggs than chicken, but the hen can also be slaughtered for meat at the end of her productive life, and eggs are an important source of protein, used in a wide variety of foods.[26]

Dairy production would also decline, by around a fifth. This is due to a fall in milk yields, brought about by a reduction in the amount of cereals used for feed as part of the shift to high-welfare, grass-based systems of production.

Beef production, however, would only fall by around 8%, while lamb production would remain steady, reflecting the integral role of grazing livestock in the regenerative farming systems we have modelled. The prioritisation of grass-fed over grain-fed livestock, is clearly shown in the following figures. There would be major reductions in the number of pigs and chickens, but no reductions in overall cattle numbers, and a relatively minor reduction in sheep numbers.

Importantly, however, **there would be a redistribution of grazing livestock across the UK**. Numbers would increase in parts of the arable south and east due to their integration into mixed farming systems, whereas there would be a reduction in grazing livestock numbers in some grassland-dominated areas of the north and west, due to the de-intensification of production systems.

CHANGES IN LIVESTOCK POPULATIONS

— **Dairy cattle:** +7%
(123,000 more dairy cows)

— **Beef cattle:** - 8%
(123,000 fewer beef cows)

— **Ewes:** - 6%
(900,000 fewer breeding ewes and lambs)

— **Pigs:** - 57%
(203,000 fewer breeding sows)

— **Broilers:** - 80%
(881 million fewer birds slaughtered)

— **Laying hens:** - 37%
(15 million fewer laying birds)

CASE STUDY

Thistleyhaugh Farm and Healy Farm Northumberland

Duncan and Angus Nelless are organic livestock farmers, producing 100% pasture-fed beef and lamb, as well as free-range pork and turkey.

15 years ago, they decided that they needed to change the way the farm was operated to improve its profitability, and so they converted to organic and placed an even greater focus on grazing management.

This move to a low input, low cost, productive system has paid dividends for the farm's financial viability, enabling them to make a profit without relying on basic payments from government. It has delivered major benefits for the environment too, with visible increases in biodiversity and a reduction in the farm's carbon footprint, showing that productivity, profitability and environmental sustainability can go hand in hand.

Size: 560 hectares

— 200 hectares permanent pasture

— 170 hectares temporary grassland

— 100 hectares rough grazing

— 90 hectares of woodland, watercourse and other non-agricultural land

Food output

— **Beef:** 37 tonnes

— **Lamb:** 23 tonnes

— **Pork:** 117 tonnes

— **Poultry:** 6.8 tonnes

Number of employees

— Four full time and two part time

CASE STUDY

Hill Top Farm North Yorkshire

Situated at 800 to 1800ft above sea level, Hill Top Farm is a 100% organic and pasture-fed hill beef and sheep farm situated in the limestone uplands of Malham, in the Yorkshire Dales National Park.

Until the early 2000s, the farm was run in a fairly conventional fashion, with 800 crossbred sheep reliant on bought-in concentrate feed, and no cattle. Since then, however, Neil Heseltine and Leigh Weston have set about improving the environmental and financial sustainability of the farm, by dramatically reducing the number of sheep, introducing a 150-strong herd of Belted Galloway cattle and adopting conservation grazing practices designed to support biodiversity. This has allowed the farm to completely eliminate the use of bought-in feeds, and has not only made the farm more profitable and biodiverse, but has also improved the quality of life for Neil, Leigh and their stock. Carbon audits have also shown that these changes have enabled the farm to move from being a net source of carbon, to a net sink.

Size: 490 hectares

— 80% above the moorland line

— Much of the remaining 20% under traditional hay meadows, with some cut for winter feed

Food output

— **Beef:** 10 tonnes, plus 20 breeding females sold off the farm each year

— **Lamb:** 1.5 tonnes, plus 50 breeding females sold off the farm each year

Number of employees

— On the farm, Neil, an apprentice one day a week, plus occasional help at busy times

CHAPTER FOUR

Implications for diets and self-sufficiency

Chapter 4 — Sustainable diets

This report was inspired by a question that millions of people are now asking – 'what should I eat to be healthy and sustainable?' Our response is that we should align our diets to what the UK can sustainably produce, because without changing what we eat, it will be impossible for farmers to switch to regenerative production methods and still remain economically viable.

This chapter shows that if such a transition were enacted, there would still be sufficient supplies of each of our key, staple foods to maintain current levels of UK self-sufficiency, provided we ate differently, ate less (in line with dietary guidelines), and wasted less food.

Before presenting our findings and recommendations, it should be made clear that we are not trying to impose any particular diet on individual citizens. However, although we support every citizen's right to choose what they eat, dietary change will be necessary if we are to tackle the climate, nature and public health crises. As explained in previous chapters, it's also important to remember that the findings outlined here represent just one version of what a transition to regenerative farming might mean for diets and national self-sufficiency.

Aligning our diets to regenerative production

The figures in Table 4.1 and Figure 4.1 illustrate how the consumption of UK-grown foods might change if we were to align our diets more closely with what the UK can sustainably produce. These figures do not show what we currently consume in the UK, nor should they be read as a prescriptive diet for the future, as they exclude imports and exports. Instead, **the figures show how much UK-produced food is available per person currently, and how much would be available per person under regenerative farming conditions 10 years from now** (when the UK's population is projected to have risen to 70 million people).

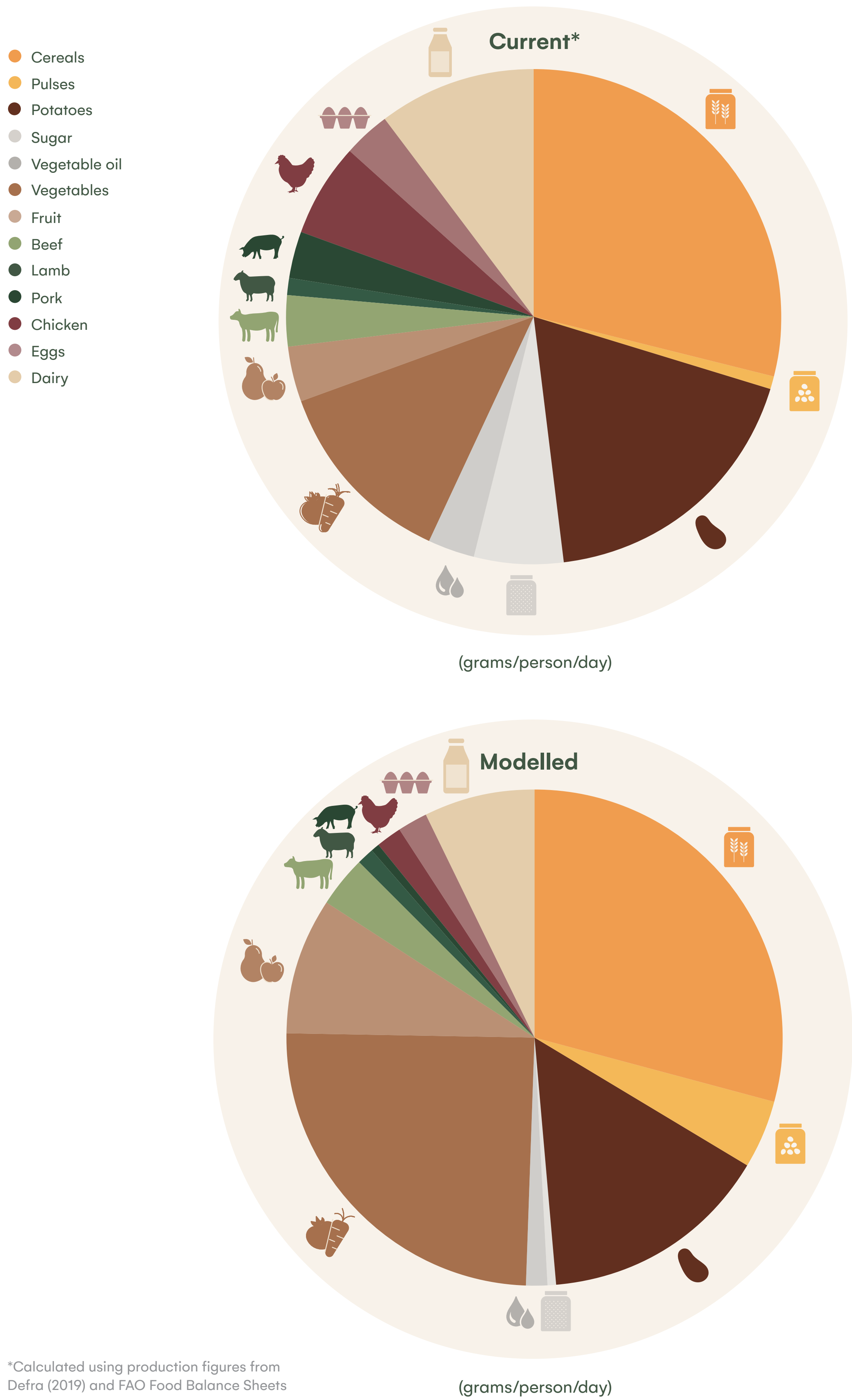
The figures have been adjusted to take into account food processing (milling to produce flour, for example) and the dairy figures refer only to the solid fraction of milk (i.e., with the weight of the liquid removed). Fish and alcohol are not accounted for in the figures, as these, while significant, fell outside of the scope of this report.

TABLE 4.1: PER PERSON AVAILABILITY OF FOOD FROM UK PRODUCTION — CURRENT VERSUS MODELLED

	CURRENT* (grams/person/day)	MODELLED (grams/person/day)	% CHANGE
Cereals	238	232	–3%
Pulses	7	35	+411%
Potatoes	149	118	–21%
Sugar	48	6	–88%
Vegetable oil	24	11	–53%
Vegetables	103	194	+88%
Fruit	29	71	+142%
Beef	28	24	–14%
Lamb	9	8	–4%
Pork	24	6	–77%
Chicken	50	13	–74%
Eggs	27	14	–48%
Dairy	82	61	–26%

*Calculated using production figures from Defra (2019) and FAO Food Balance Sheets

FIGURE 4.1: PER PERSON AVAILABILITY OF FOOD FROM UK PRODUCTION — CURRENT VERSUS MODELLED



*Calculated using production figures from Defra (2019) and FAO Food Balance Sheets

The key ingredients

As set out in Chapter 3, the nationwide transition to regenerative farming would significantly impact food production. **Here we explain the impact that our modelled changes might have on the availability of UK-produced food.**

FRUIT AND VEGETABLES

The supply of vegetables would double, with a wide diversity grown in fields and urban areas, and a significant increase in the area under unheated glasshouses and polytunnels. This would equate to around two and a half portions of vegetables per person per day.

It's a similar story with fruit, with the substantial expansion of the area devoted to fruit production and agroforestry increasing supply to a little under one portion of UK-grown fruit per person per day.

Overall, this would lead to a supply of just under three and a half portions of fruit and vegetables per day — not much less than the total amount, including imports, consumed by the average adult today. Should there be a demand for it (and crucially, the workforce to make it viable), recent studies show that it would be possible to increase UK fruit and vegetable production even further, including in urban areas.[1]

CEREALS

The combined 50% reduction in grain production and significant decrease in the amount of cereals fed to livestock mean that, per person, the amount of cereals available for human consumption would remain almost the same as at present, though with a greater diversity of grains, including more oats and rye.

Since the Second World War, the widespread availability of nitrogen fertilisers and pesticides has dramatically increased grain production and, in turn, enabled significant intensification of livestock production. These changes have transformed British diets, allowing for major increases in chicken, pork and dairy consumption.

This system has been built on a false premise — that it is cheap to produce grain in this manner. The true cost of modern-day grain production is, in fact, extremely expensive once you take into account its impact on the environment, human health and the longer-term productive capacity of farmland soils. For these reasons, we modelled a different approach to cereal production in this report, with grains grown as part of diverse crop rotations.

PULSES

Because pulses play such an important role in crop rotations (fixing nitrogen and breaking pest cycles) and contain significant levels of protein, **the availability of pulses such as peas and beans would increase significantly** — up from 7 grams of home-grown pulses available per person per day at present, to 35 grams.

Our model only includes peas and beans, but it is possible that future sustainable diets could include a wider variety of pulses, such as chickpeas and lentils, which are currently being trialled by some UK farmers.[2] The amount of pulses in our diets could be further increased by processing them into flours for use in a wide variety of products.[3] As an alternative source of protein, these products could make it easier to adapt to eating less meat.

SUGAR

Sugar is associated with major health and environmental problems and there is widespread agreement that we need to reduce the amount of sugar we consume in the UK. As a result, we have modelled a significant reduction in the amount of sugar available per person.

Currently, 60% of the nation's demand for sugar is met by UK producers in the form of sugar beet. The post-Brexit elimination of tariffs on imported cane sugar have sparked concerns that British producers could be undercut.[4] However, with sugar intake well in excess of current recommendations and sugar beet production linked to soil erosion and the use of otherwise banned neonicotinoid insecticides,[5] it is clear that reducing both UK production and consumption of sugar would benefit our health and the environment.

VEGETABLE OILS AND FATS

Like sugar beet, the availability of vegetable oils would decline significantly, largely due to the current difficulties in producing oilseed rape (by far the most significant oilseed crop grown in the UK) without the use of pesticides. Even if we assume that we would no longer use rapeseed oil for non-food uses (according to FAO data, around 30% of the UK's supply of rapeseed oil is used for these purposes), we would still see a big drop in the amount of home-grown vegetable oil available for human consumption.[6]

The major decline in availability of rapeseed oil would be partly offset by a significant increase in the availability of linseed (otherwise known as flaxseed) oil, as it is a crop that grows well in the types of regenerative farming systems modelled in this report. Promising trials showing that rapeseed oil can be produced in the UK without the use of pesticides may also enable the UK to supply significantly more vegetable oil in a regeneratively farmed future than we've assumed here.[7]

It's worth noting that animal fats would become proportionately more important in our model. While the total amount of animal fat available for consumption would fall (as a result of the reduction in total livestock numbers), our assumptions around the use of native breeds reared in pasture-based systems would see an increase in both fat content in milk and fat cover on livestock carcasses. We have also assumed that all recoverable fat trimmed from carcasses during the butchering process would enter the human food chain (at present, half is used for other purposes or wasted),[8] increasing the availability of animal fats for cooking and processing purposes.

BEEF AND LAMB

As part of the transition to sustainable food systems, we will need to move away from the consumption of intensively reared, grain-fed meat, milk and eggs. However, for the reasons outlined in earlier chapters, grass-fed and mainly grass-fed meat and dairy would form an important part of the national diet.

The amount of beef and lamb available for consumption would, therefore, fall by a modest amount, to 24 grams and 8 grams per day respectively, equivalent to about one portion of steak or beef mince a week, and around two portions of lamb mince per month.

DAIRY

As a result of the move to high-welfare, pasture-based dairy systems, average yields would decline and the overall availability and consumption of dairy products would fall by close to a third. However, the nutritional quality of dairy products would improve due to the higher percentage of grass and forage in dairy cow diets.[9]

The amount of dairy available would equate to eating no more than about 57g of hard cheese a day or drinking a little under two glasses of milk.

POULTRY AND PORK

Changes in poultry and pork consumption would constitute the most dramatic dietary change. As a result of de-intensification and the prioritisation of grain for human consumption, the amount of pork and poultry products in our diets would fall significantly.

The amount of chicken available per person would reduce by roughly 75%, from 50 grams per day, to 13 grams. This would equate to eating, on average, no more than one breast fillet of chicken every other week.

The amount of pork available per person would fall by a similar amount, from 24 grams to 6 grams per person per day, which would equate to eating no more than about two to three rashers of streaky bacon per week.

In keeping with the reductions in chicken, **the number of eggs available per person would also reduce** from about 3-4 eggs a week to 2 eggs a week.

Sustainable and healthy diets

Enabling a shift to the kinds of regenerative farming systems modelled in this study will require us to make some significant changes to what we eat. Such dietary change will also be necessary if we are to address the epidemic of diet-related disease.

At present, 63% of the UK's adult population are overweight or obese, and diseases related to obesity are estimated to cost society £27 billion a year — a figure that is predicted to almost double by 2050.[10]

While there is unanimous agreement around the need for a shift towards healthier diets, there is a more heated debate around what this should look like. **Some actions are widely agreed upon — for instance, the need to consume fewer calories, less sugar, refined carbohydrates and processed meat, and more fruit, vegetables and pulses. Our results show these are all changes that a shift to regenerative farming systems would help promote.**

The question of how much animal-sourced food we should eat is more contentious — particularly when it comes to red meat and saturated fats. Various studies have linked these foods to a higher risk of disease and death,[11] while only a few studies have found the opposite.[12] As a result, calls to dramatically reduce, or even eliminate, our consumption (and therefore production) of beef and lamb have been growing.

There have, however, been questions raised about the strength of evidence used to support the link between red meat and poor health.[13] Beef and lamb are also nutrient-dense foods which can be produced from grass and other human-inedible feeds, providing a supply of key nutrients and calories that is additional and complementary to that obtained from crops. At a time of growing pressure on arable land, there is therefore a risk that significantly reducing or eliminating our consumption and production of these foods might have negative impacts on food security, particularly in relation to protein, fat and micronutrient supply — a serious and growing concern following the disruptions to global food trade precipitated by the war in Ukraine, along with extreme weather in many food producing regions of the world.

It's also important to note that the amount of red meat available per person in our model is well below the maximum recommended daily intake of 70 grams per day, and so is in line with government health advice.[14]

Whilst there are many other important aspects to the discussion around diets and health, including the supply and availability of micronutrients essential for human health, examining these in detail was not within the scope of this report. We therefore acknowledge that the debate around what constitutes the most nutritious and balanced diet will continue. Instead, **our modelling is based on the premise that sustainable diets should be shaped from the ground up**, i.e. according to what UK farmers can sustainably produce. This 'bottom-up' approach differs from some previous reports, such as the recommendations made in the EAT-Lancet report, which were based on an assessment of the health impacts and environmental footprints of different foods.[15]

Future food security

Many readers of this report will now be wondering what aligning our diets to the sustainable productive capacity of the UK would mean for the UK's self-sufficiency.

In an attempt to answer this question, we first looked at the contribution that regenerative UK production could make to our intake of calories and macronutrients and compared this to the potential contribution from UK production at present, as is shown in the first columns of Tables 4.2 and 4.3. These figures were calculated using data on the calorie and macronutrient contents of different foods.[16]

While these results show that regenerative farming can make a significant contribution to the nation's supply of calories and key nutrients, the amount of food available per person from UK production would decline due to the fall in yields.

Clearly, importing more food to cover this decline in production would render the move to a more regenerative way of farming at home futile. In addition to exporting our environmental impact abroad, UK farmers would risk being undercut by cheaper foods, often produced to lower standards, ultimately undermining their ability to farm sustainably. However, we also know that what we currently eat as a nation is not only well beyond our share of planetary resources but also bad for our health.

This then raises the question of what would happen to the UK's self-sufficiency if we ate more healthily as a nation? Would we be able to avoid the massive increase in imports that a more regenerative approach to food production would otherwise entail?

The below figures should be interpreted as approximate values, indicating in broad terms how self-sufficiency would change between the present day and in a sustainably farmed future, assuming a change in diets. However, as a comparison of the final columns in Tables 4.2 and 4.3 show, the answer to the above question is yes — **if we ate according to the recommended intake levels for calories and macronutrients, the UK would be able to maintain its current levels of self-sufficiency in the supply of calories, protein, fat and carbohydrates, and perhaps even improve on them.**

One important issue not captured in these calculations is the supply of key micronutrients, which went beyond the scope of this report. There is, however, significant evidence to suggest that the transition towards grass-fed meat and dairy, plus the increasing UK production of fruit and vegetables, would increase the density of micronutrients in foods produced from regenerative farming systems in the UK.[17]

Another important issue relating to self-sufficiency that is not captured in these figures, is the import of animal feed. At present, the UK imports a variety of ingredients for livestock feed, but the most significant in terms of environmental impact is soya bean meal. The UK currently imports approximately 3 million tonnes of soya, grown on an overseas area almost the size of Wales; at least 75% of this is used for livestock feed, either as imported soya meal itself, or 'embedded' in imported livestock products fed with soya, principally chicken and pork.[18]

This comes at a huge environmental cost and represents a major part of our overseas footprint, yet the import of these 'shadow acres' is often overlooked in discussions around the sustainability of food production. **For these reasons, our assumption around the elimination of imported soya bean meal would reduce the UK's hidden overseas land footprint,** delivering major benefits for the environment.

TABLE 4.2: CURRENT CONTRIBUTION OF UK FARMING TO THE DEMAND FOR CALORIES AND MAJOR NUTRIENTS (ASSUMING CURRENT DIETS)

	SUPPLY FROM CURRENT UK FARMING* (per person)	CURRENT DEMAND** (per person)	% OF CURRENT DEMAND MET BY CURRENT UK FARMING
Calories	2323	3380	69%
Protein	89	105	85%
Fat	73	139	53%
Carbohydrates	353	428	83%

* Production figures from Defra (2019) ** From FAO Food Balance Sheets

TABLE 4.3: MODELLED CONTRIBUTION OF REGENERATIVE UK FARMING TO THE DEMAND FOR CALORIES AND MAJOR NUTRIENTS (ASSUMING RECOMMENDED INTAKE)

	SUPPLY FROM SUSTAINABLE UK FARMING (per person)	RECOMMENDED INTAKE* (per person)	% OF AVERAGE RDI MET BY SUSTAINABLE UK FARMING
Calories	2026	2300	88%
Protein	79	50	158%
Fat	61	90	68%
Carbohydrates	308	294	105%

* Figures taken from EFSA, with fat and carbohydrate totals being the average of a recommended range.

Key issues and discussion points

FOOD WASTE

In the UK, over 7% of all harvested food is wasted before it even leaves the farm,[19] with 22% being wasted beyond the farmgate.[20] As explained in earlier chapters, our current food system also wastes a vast number of calories and key nutrients through the feeding of large quantities of human-edible feed to livestock. In recognition of the enormous harm this causes to the environment, we decided to model a 50% reduction in food waste, and a major reduction in the amount of cereals fed to livestock.

By reducing food waste and the amount of cereals given to livestock, we would be able to maintain or increase our current levels of self-sufficiency in human-edible cereals, pulses, fruit and vegetables (as can be seen in Figure 5.2 of the full version of this report). The difference in cereals is particularly notable because so much of the UK's cereal crop is currently fed to livestock. What is also clear, however, is that **without a change in diets, we would need to import much more rapeseed oil, sugar, meat and eggs, and this is why dietary change is so important.**

INTERNATIONAL TRADE

Although our findings indicate that the UK would be able to maintain, and likely improve upon, its current levels of self-sufficiency, we would need, and indeed want, to continue trading certain foods with other countries in the future.

The UK has a relatively high population density in relation to its farmland area. In addition, a high proportion of farmland has relatively limited productivity because it is only suitable for growing grass. By way of comparison, France has a similar-sized population to the UK but has over one and a half times as much farmland and three times as much arable land.[21] As such, it is unsurprising that some food imports to the UK would still be necessary to meet the requirements of a healthy diet.

For instance, the figures in Table 4.3 suggest that we would need to continue importing sources of fat. If, however, we were to eat according to the recommended levels of intake set out in the same table, we wouldn't have to import quite as much as we to today. As discussed elsewhere, the need to import fats could be reduced further still, by assuming a larger area of oilseeds and a greater fat cover on animals than we modelled. Despite a major increase in production, we would also need to continue importing fruit and vegetables (though again, to a lesser extent than currently) if we wanted to follow the recommended five or more portions per day.

Other foods like tea, coffee, chocolate, bananas and rice, cannot be grown in the UK's climate and would therefore continue to be imported. There are, of course, important issues around the sustainability of producing and importing these foods, which should be factored into the decisions made by government, companies and consumers alike.

In addition, some key commodities are subject to long-standing reciprocal trading arrangements. As an example, while we export approximately a third of our lamb to Europe, we also import a similar amount from New Zealand.[22] This is due to the demand for prime lamb in the spring, when most lambs are only just being born in the UK. This could be changed over time if consumers could be encouraged to eat more mutton and hogget in the spring. Another example is the UK's import of large quantities of hard milling wheat from France and some other countries to make the type of loaves currently favoured here. We export a similar quantity of soft milling wheat (especially to France) which is more suitable for making the baguettes favoured by the French.[23]

In relation to other exports, and with food security in mind, if the farmers of any nation can produce a genuine surplus of a food commodity which is in deficit in other countries, or if it is possible to add value to primary commodities such as milk and grain, and there is a demand for such products overseas, it would be inappropriate not to support such trading activity.

However, it is crucial that where international trading does occur, the sustainability of production should be taken into account, with robust standards applied to all imports, and any products which fall below these standards being subject to tariffs.

Our modelling is based on the assumption that it is preferable for any nation to produce as many of its staple food requirements as is compatible with sustainability objectives, and to move to an international trading platform only if the conditions outlined above are met.

CHAPTER FIVE

Conclusions and recommendations

Chapter 5 — Conclusions and recommendations

Ensuring the long-term sustainability and resilience of the food system will require nothing short of the most radical transformation of agriculture seen in the last two generations. Despite being a major challenge, such a transition would unleash the potential of farming to help address climate change, reverse biodiversity loss, reduce diet-related disease and improve food security.

This must be considered in the context of short- *and* long-term solutions. The war in Ukraine, COVID-19 and the cost-of-living crisis all present serious issues which need to be addressed with urgency to prevent famine, poverty and a financial crisis for farmers.

The question then, is how do we respond? We have a choice. We can either continue down the road of industrial farming, producing food that is damaging to our health, the environment and long-term food security, or we can look to accelerate the transition to more regenerative, resilient farming systems and, ultimately, ensure everyone has access to healthy, sustainable food.

Conclusions

LAND USE CHANGE

A nationwide transition to regenerative farming would dramatically alter the UK's countryside, creating a much more diverse and resilient landscape.

To reduce our reliance on non-renewable inputs and restore our soils, there would be a general shift to mixed farming systems on croppable land. The reintroduction of well-designed rotations including a fertility-building phase would increase the area under temporary grassland in regions currently dominated by arable, while crop, fruit and vegetable production would return in some predominantly grassland areas.

Another landscape-scale change would be the move from intensive to pasture-based systems of livestock production, and a redistribution of sheep and cattle across the country. Whilst numbers would fall in intensively grazed grassland areas, they would increase in areas currently dominated by arable, due to their key role in the fertility-building process.

There would also be major increases in agroforestry and woodland cover, and in the area of land allocated to nature restoration, particularly in the uplands, which would help deliver major benefits for biodiversity and the climate.

FOOD PRODUCTION

According to our model, a greater diversity of crops would be grown, including major increases in the amount of fruit, vegetables and pulses. However, the production of oilseeds and sugar beet would decline, as these are, at present, difficult to grow without the use of synthetic inputs.

Significantly less grain would be produced, with these crops mainly being used for direct human consumption rather than livestock feed. This change, along with the end of imported protein feeds for livestock, **would result in a significant fall in the production of pork and poultry.**

In contrast, though the methods of production would change, **cattle and sheep numbers would fall only slightly, reflecting the critical importance of grazing livestock in sustainable and regenerative farming systems.** The production of **dairy would, however, fall by a fifth**, due to the decreased milk yields associated with pasture-based systems and a reduction in the amount of grain being fed.

DIETS

Overall, the nationwide transition to sustainable farming would lead to **increased availability of UK-grown seasonal vegetables, fruit and pulses**, and roughly the same amount of grain-based foods, but from a greater variety of cereals including more oats and rye.

The amount of beef and lamb available for consumption would fall by a modest amount, to 24 grams and 8 grams per day respectively. In contrast, a transition to sustainable farming would result in **significantly less chicken, eggs and pork in our diets.**

SELF-SUFFICIENCY

Following a transition to sustainable farming, our results show that existing levels of self-sufficiency in calories and macronutrients could be maintained and even improved upon, but only if we ate differently, ate less and wasted less food.

The elimination of imported protein feeds, assumed because of the devastating environmental impacts associated with their production, would help to reduce the UK's overseas land footprint even further.

International food trade would remain important in the future, but ideally should be limited to products that cannot be grown in the UK (or where there are structural deficiencies) and which meet high environmental, animal welfare and food safety standards.

Recommendations

Enabling the transition to sustainable food and farming systems in the UK will only be achievable if there is significant support from government, the financial community, retailers and the public.

FARMING PRACTICE

Transitioning to regenerative agriculture, with its greater diversity of enterprises, would require many farmers to change their farming practices, and necessitate a **programme of upskilling and knowledge exchange for farmers and advisors.**

GOVERNMENT POLICY

A range of policies would need to be introduced to collectively support and enable the regenerative transition regionally, nationally and globally. Joined-up thinking would also be necessary to ensure that educational, economic and trading policies work together to support the transition.

In recognition of the strategic importance of UK food production, we strongly recommend that the agricultural support budget be maintained, if not increased, without reducing the budget currently allocated for nature recovery. Without this, there would not be a strong enough financial case for farmers to make the transition.

Linked to this, we suggest the introduction of an annual whole-farm sustainability assessment as a condition for the receipt of government subsidies. This is essential to support farmers in improving their practices, and the government in monitoring the delivery of public goods. We can only justify the continued use of taxpayers' money to support agriculture if we measure the public benefits and illustrate the value that the farming community deliver to the environment and society.

In order for sustainable farming systems to become more profitable than the current extractive agricultural model, the external, hidden costs of food production would need to be reflected in the price of food. Policies and systems of financial support that discourage unsustainable farming practices and encourage sustainable ones would be needed.

We also strongly recommend the application of the polluter pays principle to ensure that all farmers, land managers and manufacturers of agricultural inputs are financially accountable for any negative impacts their practices and inputs have on the environment and human health. **This would ensure that the most damaging practices are eventually phased out** and would help address the problem of dishonest food pricing.

FINANCE

Unless the kind of farming systems recommended in this report are made profitable for farmers and affordable for consumers, a large-scale transition will not be possible. Accordingly, the introduction of finance schemes, incorporating measures such as discounted interest rates for farmers who can demonstrate sustainability improvements, would be essential.

Private sector investment in farming systems that deliver measurable improvements to natural and social capital would also have an important role to play, though this would need to be properly regulated and should take a holistic view of sustainability.

INFRASTRUCTURE

Enabling food distribution systems that support regenerative farming would require serious investment in local infrastructure. For example, more local abattoirs and butchers would be needed to support smaller scale and relocalised livestock production, and a greater number of vegetable packing houses would be required in the west of the country to facilitate an expansion in vegetable production. Parallel investment would be needed in skills and people to work in and manage such facilities and services.

Embracing the principles of the circular economy would also require investment (as well as changes in regulation), for instance in the building of facilities to process food waste safely into animal feed and to compost and recycle abattoir waste.

PUBLIC ENGAGEMENT

Education would have a key role to play in building a consensus around what constitutes a sustainable and healthy diet. Therefore, **the food sector would need to provide tools and information to enable the public to make informed choices.**

Targeted public campaigns and better education on food, farming and cooking, alongside increased opportunities for participating in the food system (such as involvement in food growing initiatives), would all help to advance public understanding.

FOOD MARKETS AND PUBLIC PROCUREMENT

Food companies and retailers have a major role to play in ensuring producers are paid a fair price for their products, and that consumers are given full transparency about where and how the food they purchase has been produced. Supply-chain transparency and commitments around sustainable sourcing would be key to this.

To make it easier for citizens to identify sustainably produced foods, clear food labelling, underpinned by a common set of sustainability metrics, would be necessary. Creating markets for local, sustainably produced food would also be vital. Public sector food procurement, in schools, hospitals, prisons and government departments should be centred around seasonal and sustainably produced foods from UK farmers.

INTERNATIONAL TRADE

Transitioning to a sustainable food and farming model has huge implications for international trade. It will be very difficult for UK farmers to produce food sustainably if they have to compete with imports of cheaper foods produced to lower environmental and welfare standards abroad.

Government should therefore set a new framework for trade, based on the sustainability of production, whereby robust standards are applied to all imports, with any that fall below these being subject to tariffs. Developing a globally recognised set of sustainability metrics would be important in achieving this.

FOOD POVERTY

We are already entering a new chapter in the economy of food, with one in four households in the UK estimated to be food insecure, according to The Food Foundation. This represents a major challenge for government.

The transition to sustainable farming is likely to result in an increase in the cost of food, significantly affecting those on low incomes. Therefore, **government must act to ensure that every citizen, regardless of financial position, has access to healthy, sustainable food.**

There are various policy interventions that could be made, including the subsidisation of healthy and sustainable foods for those on low incomes, with revenues provided by the taxation of foods with major environmental and health impacts. However, these actions would only go so far and **ultimately poverty itself needs to be tackled in order to allow a full and lasting transition to a more sustainable food system.**

RESEARCH

There are huge opportunities for agricultural research and innovation, which if developed, could improve the efficiency, productivity and sustainability of farming practice.

We recommend direct partnerships between producers and researchers, to further research in areas such as soil and animal microbiomes, epigenetics, breeding crop varieties specifically selected for farming systems which use minimal amounts of synthetic inputs, and alternative sources of livestock feed to reduce greenhouse gas emissions.

MEASURING SUSTAINABILITY

Most of the recommendations outlined above will be enhanced and underpinned by sustainability measurements, from the ground up.

A growing coalition of farmers, farm advisors, scientists, retailers, financial institutions, government actors and NGOs are now forming behind the need for a common framework for defining and measuring sustainability at farm level. The outcome of this has been the development of the Global Farm Metric (GFM) — a set of categories and subcategories that measure and define the social, economic and environmental impacts of all farming systems. If adopted, this framework could be embedded into existing farm audits, assessments and certification schemes so that all are aligned and have a common starting point of farm-level data collection.

Ultimately, the GFM would provide a common language for farm and land use sustainability, which would then inform better understanding, practice and policy and help shift the balance of financial advantage towards more sustainable food and farming systems.

FIGURE 5.1: GLOBAL FARM METRIC — THE 11 MEASUREMENT CRITERIA

References

CHAPTER 1

1. Fraanje, W. (2018) What is the land sparing-sharing continuum? (Food Climate Research Network, University of Oxford. Available at https://www.tabledebates.org/building-blocks/what-land-sparing-sharing-continuum
2. UNEP. Worldwide Food Waste (United Nations Environment Programme). Available at https://www.unep.org/thinkeatsave/get-informed/worldwide-food-waste
3. FAO (2012) Livestock and Landscapes (Food and Agriculture Organisation of the United Nations). Available at https://www.fao.org/3/ar591e/ar591e.pdf
4. Cassidy, E. et al (2013) Redefining agricultural yields: from tonnes to people nourished per hectare, *Environmental Research Letters* **8**: 034015
5. Mellanby, K. (1975) *Can Britain Feed Itself?* (The Merlin Press)
6. Fairlie, S. (2007) Can Britain Feed Itself?, *The Land* **4**, 18–26.
7. Jones, P. and Crane, R. (2009) England and Wales under organic agriculture: how much food could be produced? (Centre for Agricultural Strategy, University of Reading)
8. Smith, L. et al (2018) Modelling the production impacts of a widespread conversion to organic agriculture in England and Wales, *Land Use Policy* **76**, 391–404.
9. Poux, X. et al (2021) Modelling an agroecological UK in 2050 – findings from TYFAREGIO (Paris: Institute for Sustainable Development and International Relations).

CHAPTER 2

1. UNEP (2021) Environmental and health impacts of pesticides and fertilisers and ways of minimising them (United Nations Environment Programme). Available at https://wedocs.unep.org/xmlui/bitstream/handle/20.500.11822/34463/JSUNEPPF.pdf?sequence=13
2. Berner, A. et al (2016) The Basics of Soil Fertility: Shaping our Relationship to the Soil (Research Institute of Organic Agriculture FiBL and Organic Research Centre). Available at https://www.organicresearchcentre.com/wp-content/uploads/2020/09/4002-soil-fertility.pdf
3. Rowntree, J. et al (2020) Ecosystem impacts and productive capacity of a multi-species productive livestock system, *Frontiers in Sustainable Food Systems* **4**.
4. PACE (2021) Circular Economy Action Agenda: Food (Platform for Accelerating the Circular Economy in partnership with Resonance). Available at https://pacecircular.org/action-agenda/food
5. FFCC (2021) Agroecology as a Nature-based Solution: APPG inquiry submission (Food Farming and Countryside Commision). Available at https://ffcc.co.uk/assets/downloads/FFCC_Agroecology-as-a-nature-based-solution_May21.pdf
6. Smit, L. and Heederik, D. (2017) Impacts of Intensive Livestock Production on Human Health in Densely Populated Regions, *GeoHealth* **1**, 272–277.; Menzi, H. et al, Impacts of intensive livestock production and manure management on the environment. In Steinfeld, H. et al (eds) (2010) *Livestock in a changing landscape. Volume 1. Drivers, consequences, and responses* (Washington, D.C: Island Press); CiWF and WSPA (2013) Zoonotic Diseases, Human Health and Farm Animal Welfare (Compassion in World Farming and World Society for the Protection of Animals). Available at https://www.cabi.org/vetmedresource/news/23075
7. Müller, A. (2015) The role of Livestock in Agroecology and Sustainable Food Systems. In *Feeding the People: Agroecology for Nourishing the World and Transforming the Agri-Food System* (IFOAM EU Group, Brussels, Belgium) chapter 6, pp. 30–33.; Van Zanten, H. et al (2019) The role of farm animals in a circular food system, *Global Food Security* **21**, 18–22.
8. SA (2015) Factsheet: Organic Crop Rotation (Soil Association). Available at https://www.agricology.co.uk/resources/organic-crop-rotations#:~:text=A%20good%20rotation%20will%20help,costs%20and%20reduce%20financial%20risks
9. Natural England (2006) The importance of grazing livestock for wildlife conservation (Peterborough: English Nature). Available at http://publications.naturalengland.org.uk/publication/68026
10. Cassidy, E. et al (2013) Redefining agricultural yields: from tonnes to people nourished per hectare, *Environmental Research Letters* **8**: 034015
11. zu Ermgassen, E. et al (2016) Reducing the land use of EU pork production: where there's swill, there's a way, *Food Policy* **58**, 35–48
12. Soil Association (2022) *Peak Poultry – briefing for policy makers*. Available at https://www.soilassociation.org/media/22930/peak-poultry-briefing-for-policy-makers.pdf
13. Raskin, B. and Osborn, S. (eds) (2019) *The Agroforestry Handbook: Agroforestry for the UK* (Bristol: Soil Association)
14. *Ibid*
15. Barbour, R. (2021) Agroforestry: an ancient practice with a promising future? (Sustainable Food Trust). Available at https://sustainablefoodtrust.org/articles/agroforestry-an-ancient-practice-with-a-promising-future/
16. Grafius, D. et al (2020) Estimating food production in an urban landscape, *Scientific Reports* **10**: 5141
17. Cassidy, E. et al (2013) Redefining agricultural yields: from tonnes to people nourished per hectare, *Environmental Research Letters* **8**: 034015
18. WRAP. The Courtauld Commitment 2030: Reducing food waste, cutting carbon and protecting critical water resources (Waste and Resources Action Programme). Available at https://wrap.org.uk/taking-action/food-drink/initiatives/courtauld-commitment
19. Van Hal, O. et al (2019) Accounting for feed-food competition in environmental impact assessment: Towards a resource efficient food-system, *Journal of Cleaner Production* **240**: 118241
20. Poux, X. et al (2021) Modelling an agroecological UK in 2050 – findings from TYFAREGIO (Paris: Institute for Sustainable Development and International Relations)
21. Feniuk, C. et al (2019) Land sparing to make space for species dependent on natural habitats and high nature value farmland, *Proceedings of the Royal Society B Biological Sciences* **286**: 1909
22. Defra (2019) Agriculture in the United Kingdom (Department for Environment, Food and Rural Affairs; Department of Agriculture, Environment and Rural Affairs (Northern Ireland); Welsh Government, Knowledge and Analytical Services; The Scottish Government, Rural and Environment Science and Analytical Services). Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/950618/AUK-2019-07jan21.pdf
23. MAFF (1988) Agricultural Land Classification of England and Wales: Revised criteria for grading the quality of agricultural land (ALC011) (Ministery of Agriculture, Fisheries and Food) Available at http://publications.naturalengland.org.uk/category/5954148537204736
24. JHI. Land capability for agriculture in Scotland (James Hutton Institute). Available at https://www.hutton.ac.uk/learning/exploringscotland/land-capability-agriculture-scotland
25. Roos, E. et al (2018) Risks and opportunities of increasing yields in organic farming: a review, *Agronomy for Sustainable Development* **38**: 14
26. Bedoussac, L. et al (2015) Ecological principles underlying the increase of productivity achieved by cereal-grain legume intercrops in organic farming. A review, *Agronomy for Sustainable Development* **35**, 911–935
27. Murphy, K. et al (2005) Breeding for organic and low-input farming systems: An evolutionary—participatory breeding method for inbred cereal grains, *Renewable Agriculture and Food Systems* **20**, 48–55
28. Qadir, M. et al (2020) Global and regional potential of wastewater as a water, nutrient and energy source, *Natural Resources Forum* **44**, 40–51; Wollman, I. and Kurt, M. (2015) *Assessment of Alternative Phosphorus Fertilizers for Organic Farming: Sewage Precipitation Products* (Research Institute of Organic Agriculture FiBL)
29. ONS (2019) National Population Projections: 2018-based (Office for National Statistics) Available at https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/nationalpopulationprojections/2018based
30. Public Health England (2021) McCance and Widdowson's The Composition of Food Integrated Dataset. Available at https://www.gov.uk/government/publications/composition-of-foods-integrated-dataset-cofid
31. EFSA (2017) Overview on Dietary Reference Values for the EU population as derived by the EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA) (European Food Safety Authority).
32. FAOStat, *Food Balances (2010-)*, Food and Agriculture Organisation of the United Nations. Available at https://www.fao.org/faostat/en/#data/FBS

CHAPTER 3

1. Committee on Climate Change (2020) *Land use: policies for a net zero UK*
2. Lampkin, N. et al (2014) 2014 *Organic Farm Management Handbook* (Organic Research Centre)
3. Bowman, M. et al (2019) *Too much of a bad thing: the use and misuse of UK soil and land to grow sugar* (London: Feedback)
4. Briefing: *Farming sugar beet without neonicotinoids* (Friends of the Earth, Buglife and Pesticide Action Network)
5. Gillbard, E. (2020) How Scottish organic OSR growers delivered yields up to 3.1t/ha (Farmers Weekly). Available at https://www.fwi.co.uk/arable/osr/how-scottish-organic-osr-growers-delivered-yields-up-to-3-1t-ha
6. Poux, X. et al (2021) Modelling an agroecological UK in 2050 – findings from TYFAREGIO (Paris: Institute for Sustainable Development and International Relations).
7. Conservation Evidence: providing evidence to improve practice. Reduce fertiliser, pesticide or herbicide use generally. Available at https://www.conservationevidence.com/actions/139
8. Beillouin, D. et al (2020) Benefits of crop diversification for biodiversity and ecosystem services, Global Food and Nutrition Security
9. Feber, R and MacDonald, D. Biodiversity in crops and grassland (Wildlife Conservation Research Unit, University of Oxford) Available at https://www.agricology.co.uk/sites/default/files/Crops%20and%20grassland.pdf
10. Garibaldi, L. et al (2020) Working landscapes need at least 20% native habitat, *Conservation Letters* **14**
11. Torralba, M. et al (2016) Do European agroforestry systems enhance biodiversity and ecosystem services? A meta-analysis, *Agriculture, Ecosystems and Environment* **230**, 150–161
12. Feniuk, C. et al (2019) Land sparing to make space for species dependent on natural habitats and high nature value farmland, *Proceedings of the Royal Society B Biological Sciences* **286**: 1909
13. Natural England (2006) The importance of grazing livestock for wildlife conservation (Peterborough: English Nature). Available at http://publications.naturalengland.org.uk/publication/68026
14. Johnston, A. et al (2017) Changes in soil organic matter over 70 years in continuous arable and ley-arable rotations on a sandy loam soil in England, *European Journal of Soil Science* **68**, 305–316
15. Committee on Climate Change (2020) *Land use: policies for a net zero UK*; Crossland, M. (2015) The carbon sequestration potential of hedges managed for woodfuel (The Organic Research Centre). Available at https://www.organicresearchcentre.com/manage/authincludes/article_uploads/project_outputs/TWECOM%20ORC%20Carbon%20report%20v1.0.pdf
16. Pereira, H. and Navarro, L. (eds) (2015) *Rewilding European Landscapes* (Springer)
17. Conant, R. et al (2017) Grassland management impacts on soil carbon stocks: a new synthesis, *Ecological Applications* **27**, 662–668
18. Menegat, S. et al (2022) Greenhouse gas emissions from global production and use of nitrogen synthetic fertilisers in agriculture, *Scientific Reports* **12**, 14490
19. Gil, J. (2020) Carbon footprint of Brazilian soy, *Nature Food* **1**, 323
20. Robinson, R. et al (2002) The importance of arable habitat for farmland birds in grassland landscapes, *Journal of Applied Ecology* **38**, 1059–1069
21. Oxford Martin School (2018) *Climate metrics for ruminant livestock* (University of Oxford, Oxford Martin School) Available at https://www.oxfordmartin.ox.ac.uk/downloads/reports/Climate-metrics-for-ruminant-livestock.pdf
22. Morrison, S. et al, 2022, Net zero and livestock: how farmers can reduce emissions. Centre for Innovation Excellence in Livestock; 'Impact of livestock disease on greenhouse gas emissions', Farming for 1.5: Independent inquiry on farming and climate change in Scotland. Available at https://www.farming1point5.org/_files/ugd/a7353c_692c70b3a81843f49da2a44952dc7d16.pdf
23. SEFARI, *Breeding to reduce methane emissions from beef cattle*. Available at https://sefari.scot/research/breeding-to-reduce-methane-emissions-from-beef-cattle
24. Poux, X. et al (2021) *Modelling an agroecological UK in 2050 – findings from TYFAREGIO* (Paris: Institute for Sustainable Development and International Relations).
25. AHDB (2020) *UK cereals supply and demand estimates.* Available at https://projectblue.blob.core.windows.net/media/Default/MI%20Reports/BST/UK%20Supply%20and%20Demand/201920/201920%20-%20Sep%20update.pdf
26. Shepon, A. et al (2016) Energy and protein feed-to-food conversion efficiencies in the US and potential food security gains from dietary changes, *Environmental Research Letters* **11**: 105002

CHAPTER 4

1. Walsh, L. et al (2022) Potential of urban green spaces for supporting horticultural production: a national scale analysis, *Environmental Research Letters* **17**: 014052
2. PGRO (2018) *Blueprint for UK pulses in a post-Brexit world* (Processors and Growers Research Association) Available at https://www.pgro.org/downloads/PGROBLUEPRINTFORPULSES.pdf
3. *Ibid*
4. Partridge, J. (2021) 'A perfect storm': UK sugar beet growers fear Brexit threatens their future, *The Guardian*. Available at https://www.theguardian.com/politics/2021/aug/18/uk-beet-growers-fear-brexit-threatens-their-future
5. Bowman, M. et al (2019) *Too much of a bad thing: the use and misuse of UK soil and land to grow sugar* (London: Feedback); *Briefing: Farming sugar beet without neonicotinoids* (Friends of the Earth, Buglife and Pesticide Action Network)
6. FAOStat, *Food Balances* (2010-), Food and Agriculture Organisation of the United Nations. Available at https://www.fao.org/faostat/en/#data/FBS
7. Gillbard, E. (2020) How Scottish organic OSR growers delivered yields up to 3.1t/ha (Farmers Weekly). Available at https://www.fwi.co.uk/arable/osr/how-scottish-organic-osr-growers-delivered-yields-up-to-3-1t-ha
8. FAOStat, *Food Balances (2010-)*, Food and Agriculture Organisation of the United Nations. Available at https://www.fao.org/faostat/en/#data/FBS
9. Alothman, M. et al (2019) The "Grass-Fed" Milk Story: Understanding the Impact of Pasture Feeding on the Composition and Quality of Bovine Milk, *Foods* **8**: 350
10. NHS (2017) Health matters: obesity and the food environment (National Health Service). Available at https://www.gov.uk/government/publications/health-matters-obesity-and-the-food-environment/health-matters-obesity-and-the-food-environment—2
11. Papier, K. et al (2021) Meat consumption and risk of 25 common conditions: outcome-wide analyses in 475,000 men and women in the UK Biobank study, *BMC Medicine* **19**: 53
12. Wang, X. et al (2016) Red and processed meat consumption and mortality: dose-response meta-analysis of prospective cohort studies, *Public Health Nutrition* **19**, 893-905
13. Zeraatkar, D. et al (2019) Red and Processed Meat Consumption and Risk for All-Cause Mortality and Cardiometabolic Outcomes, *Annals of Internal Medicine* **171**, 703-710
14. NHS (2021) *Meat in your diet*. Available at https://www.nhs.uk/live-well/eat-well/food-types/meat-nutrition/
15. Willett, W. et al (2019) Food in the Anthropocene: the EAT—*Lancet* Commission on healthy diets from sustainable food systems, *The Lancet Commissions* **393**, 447-492
16. Public Health England (2021) McCance and Widdowson's The Composition of Food Integrated Dataset. Available at https://www.gov.uk/government/publications/composition-of-foods-integrated-dataset-cofid
17. Daley, C. et al (2010) A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef, *Nutrition Journal* **9**: 10.; Alothman, M. et al (2019) The "Grass-Fed" Milk Story: Understanding the Impact of Pasture Feeding on the Composition and Quality of Bovine Milk, *Foods* **8**: 350
18. Soil Association (2022) *Peak Poultry - briefing for policy makers*. Available at https://www.soilassociation.org/media/22930/peak-poultry-briefing-for-policy-makers.pdf
19. WRAP (2019) *Food Waste in Primary Production in the UK* (Waste and Resources Action Programme). Available at https://wrap.org.uk/sites/default/files/2020-07/WRAP-food-waste-in-primary-production-in-the-UK.pdf
20. WRAP (2021) Food surplus and waste in the UK — key facts (Waste and Resources Action Programme). Available at https://wrap.org.uk/sites/default/files/2021-10/food-%20surplus-and-%20waste-in-the-%20uk-key-facts-oct-21.pdf
21. EUROSTAT, Agricultural Census in France. Available at https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agricultural_census_in_France
22. Defra (2019) Agriculture in the United Kingdom (Department for Environment, Food and Rural Affairs; Department of Agriculture, Environment and Rural Affairs (Northern Ireland); Welsh Government, Knowledge and Analytical Services; The Scottish Government, Rural and Environment Science and Analytical Services). Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/950618/AUK-2019-07jan21.pdf
23. *Ibid*

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