Policy paper

Farming for the future:

how agroforestry can deliver for nature and climate

2022 Report

WOODLAND TRUST

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Contents

1. Executive summary

Bringing more trees into farmed landscapes will make them more resilient economically and environmentally. Trees on farms combine productivity with support for biodiversity, increasing the carbon stored in the land and helping us meet our commitments on climate and nature.

Agroforestry (significantly increasing the number of trees we incorporate into farming systems) can help deliver nature and climate goals while continuing to support agricultural production and other services that we need from the land. Research presented in this report makes clear that widespread adoption of agroforestry can enhance and connect habitats and help store more carbon in our landscapes, while maintaining food production and in some cases improving farm productivity in both arable and pastoral farming systems.

Currently, farming releases large amounts of greenhouse gas (GHG) emissions.[1] On average across the UK, arable areas release nearly two tonnes of carbon dioxide equivalent per hectare per year, and grassland areas with livestock nearly four tonnes.[2] There is strong evidence that agroforestry can make an important contribution to tackling these emissions as part of farm plans to improve land management for nature and climate.

For example:

- Over 30 years, silvoarable systems can sequester the equivalent of eight tonnes of CO_2 per hectare per year – equivalent to the average annual carbon footprint of a UK household.[3]
- Establishing silvopastoral agroforestry on 30% of UK grassland (3.35 million hectares; 84,000 hectares per year for 40 years starting in 2022) would result in net zero emissions from the grassland sector by 2050, and a net sequestration rate of 21 million tonnes of CO_2 equivalent per year by 2062.
- Allowing an existing hedge to increase in height from two to three metres can store an additional seven tonnes of carbon per hectare.

There is also good evidence that agroforestry can make an important contribution to nature recovery in England's farmed landscapes.[4]

The likely benefits to nature of adopting agroforestry have been shown to include:

- increases in the abundance and richness of farmland species, with birds and invertebrates particularly likely to benefit
- improved soil structure and functioning, with positive effects on carbon sequestration, nutrient turnover, and pollutant control and abatement
- a probable enhancement of other key ecosystems services including pollination, pest control and decomposition.

But take-up of agroforestry in England remains extremely low. Despite frequent name checking by government and strengthening evidence of its benefits, it is estimated that only 3.3% of the agricultural area of the UK is under agroforestry – less than half the European average[5]. Furthermore, there remains no comprehensive assessment of the amount or quality of agroforestry, nor of trends in expansion or loss. There are also significant cultural, economic and knowledge barriers to its adoption by farmers. So far, little action has been taken by government to address these and to encourage farmers to adopt agroforestry systems.

[1] www.gov.uk/government/statistics/agri-climate-report-2021/agri-climate-report-2021

[2] The Potential Contribution of Agroforestry to Net Zero Objectives www.britishecologicalsociety.org/applied-ecology-resources/about-aer

[3] www.theccc.org.uk/wp-content/uploads/2016/07/5CB-Infographic-FINAL-.pdf

[4] What are the Impacts of Agroforestry on nature recovery in England? www.britishecologicalsociety.org/applied-ecology-resources/about-aer/

[5] Herder, M.D et al. 2017. "Current Extent and Stratification of Agroforestry in the European Union." Agriculture, Ecosystems & Environment 241: 121–32. dspace.lib.cranfield.ac.uk/handle/1826/11883

Early and widespread adoption of agroforestry is needed now to combine productive and resilient farming with nature recovery and net zero. Without decisive action to promote and incentivise agroforestry there is a high risk that Government policy objectives for nature and climate will either be missed or met in ways that make suboptimal use of land.

Urgent steps are needed to incorporate more trees in the farmed landscape and should include:

- setting definitions and an overall national target for the adoption of different types of agroforestry
- a process for guiding new agroforestry to the most beneficial locations and avoiding and protecting important existing habitats, including through Local Nature Recovery Strategies
- major public funding for agroforestry projects through Environmental Land Management (ELM) schemes
- improved methodologies for calculating the carbon sequestration benefits of agroforestry as wider support for insetting
- investment in skills and training to improve knowledge and advice to land managers on how and where to incorporate more trees into the landscape
- investment in supply chains to support small scale markets for specialist outputs from agroforestry.

To support the measures set out above and encourage the take-up of agroforestry, the Government should work with partners to develop and deliver a coherent programme as set out in the following section.

We urgently need to incorporate more trees into farmed landscapes.

TIM SCRIVENER

Public policy reform

Targets and support to achieve the Government's climate change and nature recovery ambitions including:

- 10% of arable land to be established with silvoarable
- 10% of arable land to be planted with new hedges and shelterbelts
- 30% of pasture to be established with silvopastoral
- developing and adopting more holistic approaches to land management such as holding or catchment Land Management Plans to support nature and climate objectives, and assess and manage energy use, nutrient inputs and carbon flows
- tackling barriers to agroforestry through clearer regulation and guidance for landowners and tenants
- actively promoting agroforestry through all three ELM schemes.

Advice and training

- Improving support for employment in agroforestry and related roles through the development of a wider land use sector skills strategy. This should include input from Defra, the Department for Education, the forestry sector and land-based agricultural colleges.
- Establishing a peer-to-peer advice network for farmers and land managers considering adopting agroforestry and covering agroforestry practice across the full range of land uses and approaches.

Trees integrated into a productive farmed landscape.

HELEN CHESSHIRE/WTML

Trees integrated into a productive farmed landscape.

JEREMY GUGENHEIM

Effective funding and financing

- Targeting grant payments through ELM that reflect the long-term investment required to establish and manage trees.
- Investing in domestic tree supply capacity to meet growing demand without reliance on imported stock which carries the risk of tree disease.
- Further developing the carbon markets for agroforestry, and support 'insetting' to help farmers and food businesses work together to reduce GHG emissions (there may also be a case for considering if other market-based approaches can support the take-up of agroforestry).
- Innovation funding to examine how new small-scale agricultural products from agroforestry can be brought to the market (for example, fruit and nut growing).

Research

- Deepening the understanding of the benefits to nature and GHG emissions by undertaking detailed studies of agroforestry in a UK context.

Note: this report makes recommendations for policy development and implementation in England, however, the modelling is based on UK data.

2. Introduction

The urgent need to increase tree cover in England for climate and nature is well established[1]. This report assesses the benefits that could be achieved by incorporating different types of agroforestry at scale on farmland in England. Looking at different types of agroforestry systems, it draws on academic research and case studies of where agroforestry is already being deployed. It then sets out recommendations on the policies and funding decisions needed to bring more trees back into our farmed environment and make changes in land use a reality.

England is both one of the least-wooded places in Europe[2] with only a third the woodland cover of Germany or France[3], and one of the most nature-depleted countries in the world[4]. While the Government has committed to increasing tree cover, where those trees should go, and how we incorporate them while maintaining the other services we need from the land, is not clear.

After centuries of decline, forest cover in England is now increasing – doubling since the turn of the last century (albeit primarily in low-diversity plantations)[5]. **Expanding tree cover further is an important part of the country's response to climate change**[6]. Targets to increase tree cover by tens of thousands of hectares a year have been proposed both to sequester carbon and help ameliorate the impacts of more extreme weather.

Field trees have been lost as farm machinery has got bigger.

GEORGE IMPEY/ALAMY STOCK PHOTO

[1] https://committees.parliament.uk/publications/9364/documents/160849/default/ page 7

[2] England Trees Action Plan https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/987432/england-trees-action-plan.pdf page 3

[3] Area covered by forests in 2020 https://ec.europa.eu/eurostat/web/products-eurostat-news/-/edn-20210321-1

[4] UK has 'led the world' in destroying the natural environment https://www.nhm.ac.uk/discover/news/2020/september/uk-has-led-the-world-in-destroying-the-natural-environment.html September 2020

[5] Forestry Statistics 2021 Chapter 1: Woodland Area & Planting https://cdn.forestresearch.gov.uk/2022/02/ch1_woodland_fs2021.pdf page 9

[6] Net Zero Strategy: Build Back Greener page 83 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf

The Cornfield, a painting from 1826 by John Constable, showing an abundance of trees outside woods in Essex.

JOHN CONSTABLE, ART COLLECTION/ALAMY STOCK PHOTO

Meanwhile, the loss of trees from agricultural landscapes has gone largely unreported. Recent research by the Woodland Trust suggests that in 1850 there were estimated to be 1.2 million trees outside of woods in the Eastern Claylands of Suffolk and Essex, a potential representative area of lowland arable farmland. Of the trees present in 1850, only just over half are estimated to survive today. Similarly, since the start of the 20th century, there has been extensive but often undocumented loss of hedgerows and traditional orchards[1,2,3]. The consequences of this for nature can be seen in the long-term decline of indicator species such as farmland birds[4].

Pressing though nature and climate challenges are, the Government has made it clear that bringing more trees back into agricultural landscapes cannot be at the expense of overall food production e.g. National Food Strategy[5]. The UK Government has indicated that the level of domestic food production should not fall below the current level of about 54%[6]. Moreover, we need to find ways to reduce soil degradation, erosion, and compaction which result in losses of about £1.2 billion each year and impairs the capacity of UK soils to produce food[7]. While the drive to increase productivity was behind the loss of many farmland trees, there is now an opportunity for systems that can bring trees back in ways that maintain or enhance yields and support the environment.

Given the multiple benefits of bringing more trees into the farmed landscape, it may be surprising that agroforestry systems are not already widely employed on farmland in England. The various agroforestry systems are currently practised on as little as 3% of the county's agricultural land, (although this excludes boundary hedgerows, wood pasture and parkland) and until recently agroforestry was actively excluded from public financial support available to farmers. The promised focus on 'public money for public goods' means things are ripe for change.

If we rethink our approach to land use, we can use trees to help alter the way we farm and manage land, replacing 'business as usual' with systems and approaches which are more resilient to extreme weather, more able to store carbon, less reliant on intensive use of chemical inputs and more accommodating of the plants, animals and insects we share the land with – all while continuing to provide ourselves with good quality, affordable food.

[1] People's Trust for Endangered Species 'Traditional orchard decline' https://ptes.org/campaigns/traditional-orchard-project/traditional-orchard-decline/

[2] State of UK Woods and Trees page 36 https://www.woodlandtrust.org.uk/media/49731/state-of-the-uks-woods-and-trees-2021-the-woodland-trust.pdf

[3] 50% of UK hedgerows have been lost since WWII https://hedgelink.org.uk/campaign/national-hedgerow-week/about-hedges/

[4] Bird indicators https://www.bto.org/our-science/publications/developing-bird-indicators

[5] https://www.gov.uk/government/publications/government-food-strategy/government-food-strategy

[6] United Kingdom Food Security Report 2021: Theme 2: UK Food Supply Sources https://www.gov.uk/government/statistics/united-kingdom-food-security-report-2021/united-kingdom-food-security-report-2021-theme-2-uk-food-supply-sources

[7] State of the Environment, Environment Agency 2019 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805926/State_of_the_environment_soil_report.pdf

Agroforestry is a collective term for the deliberate integration of trees into farming systems. It includes traditional practices such as heritage orchard grazing, farm hedgerows and parkland, as well as innovative systems such as growing alleys of productive trees through arable land and forest farming.

Boundary agroforestry. RORY FRANCIS/WTML

Mature silvoarable. HELEN CHESSHIRE/WTML

Shelterbelt. UK AGRICULTURE

Woodland grazing. ALASTAIR HOTCHKISS/WTML

Silvopasture. AI-LAN LEE/ISTOCK PHOTOS

Fruit production silvoarable system. TOM STATTON

Silvohorticulture. PETER CROWE

3. The future of farming and the role of trees

Challenges for land use

There is growing pressure on land use in England. Among the things we need land for are:

- food production – to address food security and produce healthy affordable food
- carbon sequestration – to tackle climate change
- nature – to reverse the decline in biodiversity
- people – to provide more accessible space

Balancing these demands is complex. Currently, 68% of England's land is utilised agricultural area (UAA) (8.8 million hectares). Of this, just over half is croppable, with permanent grassland accounting for just over 40% and temporary grassland 8.5%[1]. The challenge is to improve the sustainability and efficiency of this farmed area while also restoring nature and reducing GHG emissions. This will require agricultural practices that actively restore the essential components of a healthy eco-system such as soil quality, water quality and biodiversity to produce nutrient-dense food. This is often described as "regenerative agriculture" and agroforestry is one such technique alongside no-till, cover crops, and the integration of livestock into crop rotations.

The potential of trees

Bringing more trees into our farmed landscapes is an important way of responding to the multiple pressures on land. A primary advantage of agroforestry is that it can maintain food production while providing public goods that are not supplied by many intensive farming systems.

Trees can be incorporated in many different ways.

TIM SCRIVENER/WTML

[1] Land Use on Holdings, Defra June 2021 https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june

There are numerous ways of incorporating trees into farmed landscapes. Table 1 defines the main types of agroforestry covered by this report.

Agroforestry system	Description	Forest land (official land-use classification)	Agricultural land (official land use classification)
Silvopasture	Trees in fields	Forest grazing	Wood pasture Orchard grazing Individual trees
Silvoarable	Trees in fields	Forest farming	Alley cropping Alley coppice Orchard intercropping Individual trees
Agrosilvopasture	Trees in fields	Mixtures of forest grazing and forest farming	Alley cropping and/or alley coppice and/or orchard intercropping and/or individual trees
Hedgerows, shelterbelts and riparian buffer strips	Trees between fields	Forest strips	Shelterbelt networks Wooded hedges Riparian strips

Table 1. *Defining the main types of agroforestry*[1]

The different systems of agroforestry deliver a range of environmental and farm enterprise benefits depending on how and where they are established. These include carbon sequestration, shade and shelter provision and harvestable goods (Table 2):

Shade is one of the benefits of a lowland silvopastoral system

WTML

[1] Woodland Trust Woodland Creation Guide (p53) https://www.woodlandtrust.org.uk/media/50673/woodland-trust-woodland-creation-guide.pdf

Environmental benefits	**Carbon sequestration**	As they grow, trees and shrubs store carbon both above and below ground
	Improved diversity, functioning and connectivity of habitats	An increase in tree and shrub cover expands the range and diversity of available niches, improves the provision of shelter, nesting sites and forage and enhances connectivity across what can be a hostile environment
	Water management, air quality and soil health	Agroforestry systems: ■ Improve water infiltration rates, helping to reduce surface water run-off and delay flood peaks. Trees also act as nutrient sinks minimising leaching of nitrates and phosphates ■ Create natural barriers preventing soil erosion and crop damage from impact of intense rainfall and strong winds. ■ Enhance soil health by increasing organic matter, nutrient cycling and improving soil structure. ■ Help capture ammonia emissions from livestock enterprises
Farm enterprise benefits	**Shade, shelter and browse**	■ Animal health, performance and welfare benefits from trees on farms helping to reduce temperature extremes, supporting more natural behaviours and reducing stress, as well as providing nutrition and self-medication via tree browse ■ Windbreaks enhance the microclimate for crops, improving crop water efficiency and reduce the impact of drought. Warmer soils coupled with improved water infiltration can extend the growing season of grass and its ability to carry livestock
	Other harvested products	■ Produce from trees including wood fuel or fruit and nuts. This enables a business to spread risk with a mixture of annual and perennial outputs and maximise opportunities for enhancing product value
	Additional ecosystem services	Potential income from other ecosystem services such as flood management

Table 2. *The range of environmental and farm enterprise benefits provided by agroforestry systems*

Tree browse is a valuable source of nutrition.

PATRICK BARBOUR

Agroforestry and land productivity

A well-designed and managed agroforestry system can improve farm productivity per hectare.

Alley cropping systems have proven to give greater productivity than monocultures. They can be expected to deliver a Land Equivalent Ratio (LER) of between 1-1.4 for silvoarable schemes when compared to monocultures. For example, a LER of 1.2 means there is a 20% yield advantage of the silvoarable scheme or put another way you would need 20% more land to obtain the same yield of crops and timber from separate monocultures[1].

An example of a 24-metre-wide alley silvoarable system is the apple agroforestry system established at Whitehall Farm near Peterborough by Stephen Briggs. In October 2009, 52 hectares of the organic farm with peat and clay soils, were converted to an agroforestry system using 4,500 apple trees (i.e. 86 trees ha^{-1}), covering 13 varieties (Franchella et al., 2016). Winter oats, wheat, vegetables and legume fertility-building leys have been grown in 24-metre-wide crop alleys and 3m tree strips sown with wildflowers (total width = 27m). The apples are harvested and used for juicing and direct sale. An average LER of 1.25 has been achieved since full production commenced, with gross margins of circa £1,800/ha from the tree components. At the same time the system is sequestering circa 4t of C per ha per year from the trees alone while also enhancing biodiversity.

Stephen Briggs' silvoarable scheme producing an average LER of 1.25.

Tim Scrivener/WTML

[1] Productivity and Economic Evaluation of Agroforestry Systems for Sustainable Production of Food and Non-Food Products https://mdpi-res.com/d_attachment/sustainability/sustainability-12-05429/article_deploy/sustainability-12-05429.pdf

Levels of agroforestry

Agroforestry is not widely acknowledged in land use statistics for England, but some estimates (excluding boundary hedgerows and wood pasture and parkland) have indicated that it could be equivalent to 3.3% of UK farmland. Of this, silvopasture is the dominant use[1]. This compares to the equivalent of 8.8% of the agricultural area measured across the European Union in 2012[1].

As the importance of trees on farms becomes increasingly recognised, the Government has sent strong policy signals about the role it expects agroforestry to play in the future.

For example:

> ***"Agroforestry will…play an important role in delivering more trees on farms and in our landscape, improving climate resilience and encouraging more wildlife and biodiversity in our farming systems."***
>
> England Trees Action Plan (Defra 2021)
>
> ***"We will encourage and support increased agroforestry (trees and agriculture coexisting on the same land) through our environmental land management schemes from the early 2020s, enabling agricultural land to sequester emissions while delivering other environmental benefits, such as air quality and biodiversity, and providing alternative income streams for farmers from trees."***
>
> UK Net Zero Strategy, 2021[2]
>
> ***"Agroforestry offers unique benefits to people and nature, allowing continued food production and creating new sources of income for land-managers, while also mitigating climate change and contributing to nature recovery. Recognising the importance of these benefits, the government is launching an agroforestry standard through the Sustainable Farming Incentive in 2024."***
>
> Consultation on Environment Act Targets (2022)[3]

Loss of trees from arable farms

The Eastern Claylands of Essex and Suffolk demonstrate the loss of mature farmland trees that many arable landscapes have witnessed in the last two centuries. Comparing maps from 1850 with the present day, shows that half the 1.2 million trees outside woodland have disappeared. Of the number lost, 460,000 were trees in field boundaries – more than half the original total. Scattered and lone trees were even more severely affected with only 2,000 of the 12,000 trees recorded in 1850 still in existence today[4]. The data does not record how many new trees outside woods have become established since 1850[5].

[1] Herder, Michael Den, Gerardo Moreno, Rosa M Mosquera-Losada, João H N Palma, Anna Sidiropoulou, Jose J Santiago Freijanes, Josep Crous-Duran, Joana A Paulo, Margarida Tomé, and Anastasia Pantera. 2017. "Current Extent and Stratification of Agroforestry in the European Union." Agriculture, Ecosystems & Environment 241: 121–32.

[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf

[3] https://consult.defra.gov.uk/natural-environment-policy/consultation-on-environmental-targets/

[4] Eastern Claylands covers 36,000ha. In that area, 600,000 trees outside woods have been lost since the 1850s. This is the equivalent of 17 trees per hectare. The agricultural area of England is 9.34 million hectares. Of this, 3.85m hectares is arable (36%). This is approximately the equivalent of 65,000 hectares of woodland (in terms of stems) https://www.organicresearchcentre.com/wp-content/uploads/2021/06/ORC-2020_Policy-Brief_Agroforestry_barriers.pdf

[5] *State of the UK's Woods and Trees 2021* https://www.woodlandtrust.org.uk/publications/2021/04/state-of-uk-woods-and-trees-2021/

Barriers to change

Historically, agriculture and forestry have been treated as discrete disciplines in the UK. This is reflected in education and training, end markets and supply chains as well as policies and grant support.

Before Brexit, agriculture policy was administered at EU level through the Common Agricultural Policy (CAP) while forestry was devolved to individual countries, making the integration of policy difficult. The low standing of agroforestry at this time is exemplified by the Government's decision not to adopt available measures to support agroforestry in the EU rural development regulation for CAP 2014-20, meaning no public funding was available – even to those farmers who were interested in agroforestry's potential. Recognising this lack of support, the Woodland Trust secured funding to develop our own small-scale agroforestry scheme, which we have been delivering since 2013.

With support from the Woodland Trust and others, a significant increase in interest in agroforestry within the farming sector has emerged, albeit from a very low base. But most farmers are not yet willing or able to implement it in practice. A systematic review[1] conducted as part of the Defra-funded Agroforestry ELM Test project aimed to determine what is holding farmers back from adopting agroforestry and what can be done to encourage them. The main findings were:

- Knowledge of the practice of agroforestry is very low among UK farmers. Substantial investment in agroforestry farm advisory services is needed for adoption to increase.
- Farmers consider agroforestry an activity with multiple, long-term costs. Payment mechanisms for agroforestry must reflect the long-term nature of the commitment.
- Inclusion of a specific support for agroforestry in the post-Brexit payment system would make it clear to farmers what is required of them and how they are to be paid for it.

Inaugural agroforestry conference 2017.

PHILIP FORMBY/WTML

[1] https://www.organicresearchcentre.com/wp-content/uploads/2021/06/ORC-2020_Policy-Brief_Agroforestry_barriers.pdf

Discussing silvoarable.

HELEN CHESSHIRE/WTML

There is also evidence that tenant farmers face specific barriers to the take-up of agroforestry. Although a third of farmland in England is tenanted, only 5% of farmers successfully applying for the Woodland Trust's Trees for Your Farm scheme operate solely tenanted farms. This reflects the difficulty a landlord/tenant arrangement will have in navigating a long-term land use such as woodland and trees.

Overcoming tenancy barriers

To enable greater opportunities for tenants to participate in planting trees on farms we encourage considerations to relax restrictions in relation to tree planting within tenancy agreements, coupled with incentives to lengthen letting periods. A balance needs to be created to ensure tenants have scope to integrate trees into their agricultural land without allowing widescale tree planting to be undertaken without landlord consent.

Dartington Estate in Devon has an innovative three-tiered agroforestry contract between the landowner, farm tenant and local businesses growing top-fruit and elderflowers. The landlord wanted agroforestry to be part of the farm tenancy but the tenants, although supportive of the benefits of agroforestry, felt they didn't have the necessary skills, finance, or market knowledge. The tenant then teamed up with local businesses who plant, manage, harvest and market these tree crops under a lease. This lease specifies responsibilities and management restrictions to ensure both the tree crop and the alley crop can be managed at appropriate times.

Lessons from the Woodland Trust's Trees for Your Farm scheme

The Woodland Trust's *Trees for Your Farm* scheme provides expert in-person advice and support to farmers, supplying trees and protection to successful applicants up to 100% of the costs. In return, farmers plant, establish and manage the trees and provide feedback on their agroforestry.

***Trees for Your Farm* was launched in 2013, recognising the limited farmer advice and support available for agroforestry. Funded by Sainsbury's and the PUR Project, it started small, funding six agroforestry projects in the 2013/14 season (6,500 trees) but growing year-on-year to 215 projects (and nearly 270,000 trees) delivered by the end of the 2021/22 season. The scheme is currently oversubscribed.**

Farmer Richard Bower getting Trust advice.
DEE SMITH/WTML

Key findings:

- Most farmers who have tried the scheme would recommend it to others – 87% of respondents would definitely or probably recommend tree planting to neighbouring farms.
- There is strong interest in planting more trees – 100% of the post-plant respondents and 83% of ongoing survey respondents are interested in planting more trees.
- The tree planting so far has been a success – 87% said the planting had been either good or excellent.
- The new trees are having a positive impact on wildlife habitats – 83% reported seeing more wildlife.
- The early stages are hard work. Around a third found planting harder than expected and a quarter found planning harder than expected.
- The tree planting is being noticed and good feedback is being received by the local community – two-thirds received feedback from their local community which was mostly positive.
- Ongoing support would be welcomed – a quarter wanted more advice and support than they received.

"Without this (TFYF) scheme the expected and the unimaginable benefits on our land would never have been fully realised."

"Agroforestry is at the heart of the wellbeing of our farm. In this vein the trees have brought biodiversity, fodder, harvest, increased carbon capture and improved air/soil quality."

"Planting trees is the duty of every farmer as we combat climate change and biodiversity loss"

A silvopasture system sequestering carbon while providing fodder, shade and shelter for flock.

WTML

4. Agriculture, agroforestry and climate

Introduction

This chapter considers the relationship between agroforestry, agriculture, land use and greenhouse gas (GHG) emissions. It summarises current emissions from the agriculture and land-use sectors and sets out the potential of a major expansion of agroforestry. It draws extensively on research commissioned for this report from Cranfield University[1].

Greenhouse gas emissions and agriculture

For the purposes of its GHG accounting, the UK Government measures emissions from the use of land under two categories: "agriculture" and "land use, land use change, and forestry" (LULUCF). This breaks down as:

- agriculture – greenhouse gases from livestock, agricultural soils, farm machinery and practices such as liming
- LULUCF – changes in the carbon stock of land as a result of processes including loss and gain of soil organic matter and fires. Biomass harvesting and burning is included here.

[1]The Potential Contribution of Agroforestry to Net Zero Objectives www.britishecologicalsociety.org/applied-ecology-resources/about-aer

Other emissions directly associated with agriculture, such as fertiliser production and imported animal feeds, which also carry a GHG footprint and add to the overall climate impact of the sector, are not included.

In 2019, UK agriculture emitted 46.3 Mt CO_2e, while land use, LULUCF was responsible for a further 5.9 Mt CO_2e[1]. This makes agriculture a source of 10% and LULUCF a further 1.2% of total UK GHG emissions.

Both emissions from agriculture and LULUCF have shown declines in recent decades. However, while agricultural emissions declined from 53.1 Mt CO_2e in 1990 to 45.2 Mt CO_2e in 2010, they subsequently rose to 46.3 Mt CO_2e in 2019. Key sources of the GHG emissions from UK agriculture are:

- methane from farm animals (45%)
- machinery (10%)
- direct soil emissions (21%)

GHG emissions from LULUCF have reduced from 18.0 Mt CO_2e in 1990 to 5.9 Mt CO_2e in 2019. This is the result of increases from forest land and reduced effects of historic conversion of grass and forest land to cropland (BEIS, 2019).

Upland hedgerow.

HELEN CHESSHIRE/WTML

Research findings

Cranfield University carried out a detailed assessment of the GHG impacts of agroforestry, considering different agroforestry systems (shelterbelts, hedgerows, silvoarable systems and silvopasture), soil types and tree species[2].

While the GHG impacts of agroforestry are highly dependent on local factors, a number of general conclusions can be drawn.

Without action to minimise emissions and improve land management, the agriculture sectors will continue to be sources of GHG emissions. Allocating the total agricultural sector emissions across the total UK area of cropland and grassland provides average values of:

Mature silvoarable scheme.

PAUL BURGESS

- arable farms – 1.87 t CO_2e ha^{-1} yr^{-1}
- grassland farms – 3.94 t CO_2e ha^{-1} yr^{-1}

(measured as tonnes of carbon dioxide equivalent per hectare (t CO_2e ha^{-1}) per year)

Planting trees for agroforestry can store significant amounts of carbon below ground as well as above. For example, planting shelterbelts and hedges on cropland can increase soil organic carbon by the equivalent of an average of 1.8t CO_2 per hectare of planted area per year over 40 years. Experimental results have demonstrated that silvoarable systems applied to cropland can result in an increase in soil carbon equivalent to an average of 1.1 t CO_2 per hectare per year over 30 years. This factor is not reflected in methodologies such as the Woodland Carbon Code, which seek to provide a standard methodology for quantifying carbon sequestration by trees.

[1] 2020 UK Greenhouse Gas Emissions, Final Figures, BEIS https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1051408/2020-final-greenhouse-gas-emissions-statistical-release.pdf

[2] The Potential Contribution of Agroforestry to Net Zero Objectives www.britishecologicalsociety.org/applied-ecology-resources/about-aer

Different agroforestry approaches have vastly different sequestration potential because of the number of trees involved and their management.

For example, modelled over 40 years:

- planting a silvopasture system of 400 trees ha^{-1} with livestock on grassland can achieve carbon sequestration equivalent to 16t CO_2e ha^{-1} yr^{-1}
- new shelterbelts and hedgerows, or a silvoarable system of 156 tree ha^{-1}, on cropland can achieve carbon sequestration of 7 to 8t CO_2e ha^{-1} yr^{-1}
- hedges and shelterbelts established on grassland can achieve carbon sequestration of around 6t CO_2e ha^{-1} yr^{-1}.

In determining the effect of the above systems on net GHG emissions, it is important to compare relative to mean emissions of about 4 t CO_2e ha^{-1} yr^{-1} from grassland (with livestock) and 2 t CO_2e ha^{-1} yr^{-1} from cropland. Hence the net benefit of the silvopastoral system becomes 20 t CO_2e ha^{-1} yr^{-1}, and that for shelterbelts, hedgerows and silvoarable systems on cropland becomes about 10 t CO_2e ha^{-1} yr^{-1}.

The size of the contribution agroforestry can make to achieving Government targets including net zero by 2050, will be highly dependent on the speed with which the trees can be established. For example, spreading the planting of 10,000ha of silvopasture evenly over the next 10 years reduces the estimated carbon absorption within the next 40 years by 12% when compared with establishing 10,000ha in year one.

Considered over 40 years, the implications of planting 10,000ha of agroforestry in 2023 is estimated to be:

- silvopasture systems – mean net greenhouse gas reduction of 200 kt CO_2e yr^{-1}.
- shelterbelt or hedgerow systems – mean net greenhouse gas reduction of 100 kt CO_2e yr^{-1}.

(The net greenhouse gas abatement by shelterbelts and hedgerows on grassland was similar to that on cropland with the reduction in livestock numbers providing a similar GHG benefit to ending soil cultivation).

Consideration of agroforestry is not limited to 'new' trees. Improved management of existing woody features can also bring significant carbon benefits. For example, allowing existing hedges to increase in height from two metres to three metres over five years is calculated to result in a one-off sequestration gain of 5.1 t CO_2 ha^{-1} yr^{-1}.

Future scenarios

The research considered the scale of new agroforestry that would be needed to balance the current GHG emissions from agriculture over the next 40 years. The modelling for both silvopastoral and silvoarable systems looked at the outcome of establishing between 10 and 50% of relevant agricultural land with agroforestry.

The key finding is that in scenarios where agroforestry is established on 50% of arable land and grassland, net zero could be achieved by 2037 for silvoarable (2.4m ha) and by 2044 for silvopastoral (5.6m ha) systems.

Detailed results of the modelling are set out on the following page.

Silvopasture agroforestry and carbon

To counteract GHG emissions associated with the UK's grasslands and associated livestock, just over 20% of UK grassland would need to be planted with agroforestry. This would represent 2.2 million hectares of land with around 55,000ha needing to be established each year.

Table 3 Prediction of the GHG balances from planting different proportions of UK grassland (11.18 million ha) to silvopasture

Scenario	Baseline grassland (ha)	Area of UK grassland converted to silvopasture (ha)	Annual conversion required for steady state harvesting (ha)	Steady state GHG balance after year 40 (t CO_2e yr-1)	Steady state relative livestock production (%)	Year in which net zero grassland production is achieved	Year in which net zero with 2022 is achieved	2022–2080 balance (t CO_2e)
Baseline	11,180,000			-44,049,200*	100*	–	–	-2,598,902,800
10% silvopasture		1,118,000	27,268	-22,344,024**	95**	Not achievable	Not achievable	-1,847,139,545
20% silvopasture		2,236,000	54,537	-638,849**	90**	Not achievable	Not achievable	-1,095,376,290
30% silvopasture		3,354,000	81,805	21,066,327**	86**	2051	Not achieved	-343,613,035
50% silvopasture		5,590,000	136,341	64,476,678**	76**	2044	2063	1,159,913,475

Table 3 *shows that establishing agroforestry on 10% of grassland would absorb only half the GHG emissions associated with UK grassland and associated livestock from 2022 by 2060. Under the 30%, net zero was achieved in 2051 and thereafter, sequestration exceeded emission for the UK grassland area as a whole. Meanwhile, under a scenario where 50% of UK grassland is converted to agroforestry net zero was achieved by 2044 and the rate of sequestration was sufficiently high for all emissions from UK grassland to be negated by 2063.*

Under the 10% silvoarable scenario, while sequestration by the trees and soil would not create the conditions for net zero agriculture, it did result in significant carbon absorption against a relatively limited impact on productivity.

Table 4 Prediction of the GHG balances from planting different proportions of UK cropland (4.84 million ha) to silvoarable systems

Scenario	Baseline arable land (ha)	Area of UK arable land converted to silvoarable (ha)	Annual conversion required for steady state harvesting (ha)	Steady state GHG balance after year 30 (kt CO_2e yr-1)	Steady state relative agricultural production (%)	Year in which net zero arable agriculture is achieved	Year in which net zero with 2022 is achieved	2022–2080 balance (t CO_2e)
Baseline	4,840,000			-9,051*	100*	-	-	-533,997,200
10% silvoarable		484,000	16,133	-3,812**	92**	Not achieved	Not achieved	-317,144,283
20% silvoarable		968,000	32,267	1,426**	84**	2048	Not achieved	-100,291,365
30% silvoarable		1,452,000	48,400	6,665**	76**	2042	2063	116,561,552
50% silvoarable		2,420,000	80,667	17,141**	61**	2037	2048	550,267,387

*Notes: * The steady state for the baseline is constant between 2022 and 2080.*

*** The steady state for the scenarios is achieved from 2051 – 2080 when the total area of land to be converted under each scenario is achieved. Prior to that, the silvoarable land is still being increased. This modelling is based on 150 stems/ha.*

From Table 4, the 20% scenario found that the area of land being planted each year generated sufficient sequestration to halt and gradually compensate for the GHG emissions from arable production in the UK. The point at which sufficient land was planted to achieve this was in 2048, 27 years after the first planting in 2022. However, the impact on agricultural productivity was to reduce it to 84% of baseline, requiring the adoption of agroforestry on over 32,000ha of arable land each year. These trends continued for other scenarios.

For example, the 50% scenarios meant agriculture overall would be a net carbon sink of 550,000 kilotonnes of carbon dioxide equivalent between 2022-2080, but at a cost of 39% of arable agricultural production. It should be noted that any food production from the agroforestry trees and increased productivity from any improvement to crop environment, such as soil quality, is not modelled here.

The silvoarable modelling assumed that trees would be harvested after 30 years and then replanted. The silvoarable intercrop was assumed to cover 80% of the silvoarable system for the first eight years of the rotation, after which it was assumed it would no longer be cultivated, due to declining yields resulting from competition with the tree. Duration and yield of intercrop production is impacted by alley width, tree species, and management and crop type. For example, tree management practices such as the pruning of side branches can be used to maximise light interception by the arable crop.

Silvoarable system producing crops of apples and wheat.

TIM SCRIVENER/WTML

CASE STUDY

Farming with Trees – sequestering GHG emissions

Trees are an integral part of Andrew and Seonag Barbour's family farming and forestry business in Perthshire. Farming on land that is over 1,000ft in altitude means that natural shelter is an important consideration. About 7% of the farm is now planted under a combination of shelterbelts, wood pasture and woodland blocks and they plan to add more. The trees deliver a multitude of productivity benefits, for example they estimate the shelter from grazing within trees has delivered savings of £6/sheep. After observing how their sheep and cattle interact with trees, they have now designed an alley system. This enables them to plant trees at high rates (3,000 stems/ha) suitable for commercial timber markets, while allowing livestock to graze between. The overall density is 1,600 trees/ha when the grass alleys are included.

Farm Facts:

Size:	500ha (plus 40ha forestry plantation)
Type:	Upland Livestock
Location:	Highland Perthshire

An alley system (left) allows livestock such as cattle to graze between the trees (right).

PATRICK BARBOUR

However, the trees are equally important to help the business reduce its emissions. The carbon captured by the trees has enabled the farm business to reduce net emissions by about a third. However, understanding the sources of emissions and the balance between the different enterprises' ability to sequester is key. Farmers and advisers need to know whether their carbon emissions will be judged at the business or enterprise level. By farming within trees, offsetting of emissions occurs directly from their livestock enterprise without having to lose grazing ground. This coupled with a reduction in livestock numbers as part of a more extensive farming system has directly reduced emissions from the farm.

The Barbours recognise the challenges faced by farmers in creating an emissions baseline with current carbon calculators not adequately recognising the value of trees and shrubs. To this end they have participated in carbon calculator trials. Andrew and Seonag suggest that all farmers should be supported to develop an emissions baseline and be given clarity on how surplus carbon sequestration opportunities can be marketed. For now, they will focus on wood pasture, which is proven to deliver benefits for their livestock enterprises and is approved by the Intergovernmental Panel on Climate Change.

Emissions can be cut without losing grazing ground.

PATRICK BARBOUR

5. Agroforestry and nature

This chapter summarises a review of the scientific evidence concerning agroforestry's impact on nature in the UK and other temperate climates[1].

Key findings

Abundant evidence shows that agroforestry systems can support nature by helping to increase the range and provision of:

- Microclimates, niches and habitats
- Food quality and abundance
- Shelter and egg-laying sites
- Local and landscape-scale connectivity

However, the outcomes of agroforestry interventions are site-specific and difficult to predict, owing to a range of factors, including a lack of long-term controlled experiments. Rather than being seen as a new and radical intervention, the impacts of agroforestry for nature should be assessed in a historical light; reversing a widespread loss of woody habitat features and associated practices across the English landscape, such as coppicing, traditional orchards and woodland grazing. Agroforestry can slow or reverse declines in biodiversity, alongside a suite of other sustainable farming methods. As highlighted by the Woodland Trust's recent Woodland Creation Guide, tree planting should also take place sensitively to minimise impacts on other sensitive or priority habitats where appropriate, such as calcareous grasslands.

Since the 1940s, nearly one million km of hedgerows have been lost, along with two-thirds of coppiced woodlands and a large but undocumented loss of rural trees outside woods.

We are unable to say how many trees outside woods have been lost from rural landscapes.

PAUL GLENDALE/WTML

[1] What are the Impacts of Agroforestry on nature recovery in England? www.britishecologicalsociety.org/applied-ecology-resources/about-aer

Benefits of agroforestry to nature

There is strong evidence from peer-reviewed scientific literature that agroforestry could make an important contribution to nature recovery in England's farmed landscapes. The benefits to nature of adopting agroforestry can include:

- increases in the abundance or richness of farmland species, with birds and invertebrates particularly likely to benefit
- a possible enhancement of key ecosystems services including pollination, pest control and decomposition
- improved soil structure and functioning, with positive effects on carbon sequestration, nutrient turnover, and pollutant control and abatement.

To maximise the benefits to nature, support for agroforestry should aim to prioritise:

- intensive arable settings which suffer shortages of the biodiversity benefits agroforestry can bring and are likely to see the biggest improvements
- working at catchment or landscape scale for more mobile species
- delivering a range of agroforestry approaches over time, thus contributing to complex landscapes with a variety of assemblages
- using agroforestry alongside other sustainable farming practices such as pond creation, organic farming, fallowing, cover cropping, wildflower strips, zero-tillage and restoration of hay meadows
- in some circumstances, an expansion of tree cover may favour cereal weeds, a shift in arable pest species or displace open-ground specialists.

Agroforestry benefits to specific groups

Some of the general benefits from an expansion of agroforestry are summarised below.

Redshank (Persicaria maculosa) and corn chamomile (Anthemis arvensis) are frequently found on unmown woodland egg ranges.

PAUL ARKLE

Plants

The relationship between agroforestry and plant life is complex, under-researched and closely related to management approach. Overall, agroforestry produces vegetation communities situated between agricultural land and deciduous forest, and outcomes are influenced by a broad range of factors, including seed banks or sources, former land use, soil nutrient status and cultivation. Early successional woodland can support a greater species richness than agricultural land. Conversely, dense mature coppice can eventually lead to grassland and meadow specialists being outcompeted by shade-tolerant forest species. Thus, the highest levels of diversity may be maintained by a combination of targeted interventions, such as disturbance creation and maintenance of a mosaic of differently aged tree stands.

By acting as a barrier to seed dispersal, tree alleys may favour creeping species such as creeping thistle, clovers or buttercup. Sown wildflower strips in agroforestry systems can significantly enhance floristic diversity, pollinator visits and pollen flow within and between fields. The ground beneath trees may also be colonised by arable cereal weed species, though this does not necessarily translate into increased recruitment into crops. Agroforestry vegetation can absorb nutrient run-off and pesticides, potentially protecting sensitive habitats or species. Beyond the effect of new trees, the exceptional levels of diversity hosted by veteran or ancient trees in wood pasture or hedgerows are well established, and such individuals represent a valuable genetic, ecological, and cultural resource.

Farmland birds

The inclusion of more trees in farmed environments strongly benefits birds. The availability of woody edge habitat and taller trees in particular, are significant factors supporting higher bird numbers. Trees can act as windbreaks and create new availability of forage, ground-nesting or overwintering sites. Starling, mistle thrush, fieldfare and skylark are among the many species of conservation concern known to benefit from agroforestry sites. Conversely a large expansion of farmland tree cover could disadvantage ground nesting or open farmland specialists such as yellow curlew and lapwing.

Mammals

Small mammals – including bats – are closely associated with woody habitat features. Widespread losses in traditionally managed woodland and hedgerow during the 20th century are implicated in the decline of threatened and charismatic species such as the hazel dormouse and hedgehog. Expanding and maintaining the area of these habitats is considered essential in helping to reverse these trends. The connectivity and increased habitat complexity afforded by agroforestry have also been shown to benefit a range of other small mammal species, including voles, shrews and mice.

Invertebrates

Agroforestry has been shown to increase the abundance or diversity of spiders, flies, bees, butterflies, moths, beetles and earthworms. Consequently, agroforestry is likely to affect rates of key ecosystem services such as pollination, predation and decomposition, and evidence for these effects is currently developing.

The comma butterfly inhabits woodland edges.

PAUL ARKLE

The large emerald moth feeds on birch.

PAUL ARKLE

Soil microbes

Agroforestry introduces or enhances a tree-associated microbiome to agricultural settings and can affect change in fungal and bacterial composition and soil enzyme activity. In increasing the prevalence of nitrogen-fixing or nitrifying bacteria, trees may passively enhance the nutrient status of soils, as well improving nutrient cycling or retention in agricultural catchments.

CASE STUDY

Biodiversity on poultry farms

Animal welfare has improved since trees were introduced at The Lakes Free Range Egg Company.

JONNY WALTON

Trees on hen ranges are a haven for wildlife. Over the last two decades, David Brass, chief executive of The Lakes Free Range Egg Company, has integrated 20% of his poultry ranges with a diverse mix of mainly native trees.

The result has improved both animal welfare and the quality and quantity of egg production[1]. Local wildlife has also been enhanced with annual surveys showing the created woodland edge habitat providing important habitat for birds, bats and more than 100 moth species. The ranges may also provide wildlife with some resilience to climate change, with their location helping to facilitate the northward migration of some species.

The song thrush was one of three birds on the Red List of Birds of Conservation Concern which were recorded utilising the treed hen ranges.

PAUL ARKLE

The benefits of incorporating trees can be maintained and maximised through a mixture of native tree species choice, effective management including selective thinning, and the creation of additional planted areas to create stepping-stones for wildlife to other habitat such as hedgerows and shelterbelts.[2]

[1] Laying hens go undercover to improve production A. Bright, A.D. Joret, Short Communication Veterinary Record 2012

[2] https://www.woodlandtrust.org.uk/media/49130/trees-on-hen-ranges-are-havens-for-wildlife-15064-woodland-eggs-research-briefing.pdf

CASE STUDY

Impacts of silvoarable on biodiversity and food production

David Rose's silvoarable research site on left and monocropped on far right.

ARCHIE RUGGLES-BRISE

David Rose is a third-generation farmer in Nottinghamshire who had grown concerned about the environmental impact of the intensive arable systems used on his farm. Over the last two decades, David has changed his farming practice to develop a mix of sheep, arable and agroforestry enterprises run on environmental principles using minimum tillage, direct drilling and a reduction in pesticides.

A Woodland Trust-supported silvoarable scheme incorporating fruit and nut trees was established in 2014. Research carried out over three years showed:

- strong evidence that silvoarable systems increase the diversity of plants and invertebrates compared with crop fields without trees
- managing areas beneath the trees with wildflowers enhanced environmental stewardship including for pollinators and natural pest control
- improvements in overall profitability per hectare with loss of arable productivity more than compensated for by new fruit crops.

The farm has also set up a community enterprise business, FarmEco. This provides an opportunity for people to interact with rural farming life and understand more about sustainable food production.

Pan traps catching flying insects.

TOM STATTON

Flower strips under tree rows.

TOM STATTON

6. Conclusions and recommendations

Incorporating more trees into farming systems can bring many benefits. Agroforestry's ability to support and even enhance resilient food production while delivering a wide range of benefits to nature, means national governments, farming groups and environmental organisations have all been keen to stress its virtues and highlight ambitions to increase its deployment.

Despite widespread positivity in public announcements, the take-up of agroforestry in England remains slow. Equally, initiatives that actively promote trees on farms remain notable mainly by their absence. An image persists of agroforestry as a marginal concern unrelated to mainstream farming.

The benefits from increasing tree cover on farms will not be realised without a package of measures to promote it. This must include public policy reform, long-term funding and investment commitments, target setting, research and knowledge building. Recommendations for such a package are set out, below.

Policy making

There is a clear need for Defra, Natural England, the Forestry Commission, expert NGOs and farming organisations to work in a more integrated manner to support the take-up of agroforestry. Experience of the England Woodland Creation Offer to date suggests that attractive payment rates alone will generate little interest from farmers when not backed with the active, informed and ongoing promotion needed to overcome inertia. For agroforestry, a clear thread should run from policy objectives, through regulation and funding, to targeted advice and grants to deliver on the ground.

The Government must make clear the contribution it expects silvoarable, silvopastoral and boundary agroforestry to make to national policy objectives on reducing GHG emissions and nature recovery, and how it will resource and support the increased use of agroforestry to achieve these objectives.

Agroforestry is already referenced by the Government as a tool to be used in delivering policy ambitions including carbon sequestration, nature recovery and a variety of ecosystem services. However, this support is passive and needs to be matched with a coherent picture of what the Government considers agroforestry to be, the extent it anticipates agroforestry being deployed and an overview of the ecosystem services it thereby expects to be collectively accrued. Key steps in achieving this are set out below.

Methodologies for measuring the benefit from expanding agroforestry

In recent years, the Government has set a number of targets to increase tree cover at England and UK levels. These targets primarily relate to the short-term ability of new forestry to absorb carbon and are used as part of climate change policy. The methodologies used to underpin the targets have acknowledged limitations when considering woodland being managed for conservation rather than productive timber. Such weaknesses are even more stark when considering the wide variety of spacing, stocking densities and management approaches gathered as 'agroforestry'.

Cranfield University has developed a methodology for assessing the overall GHG impact of different agroforestry systems. As part of the research underpinning this report, Cranfield's model is based on relevant real-world examples of agroforestry, differentiating

between silvoarable, silvopastoral shelterbelts and hedges, as well as soil carbon, vegetative biomass and changes to emissions associated with different livestock levels. As such, it provides a sound basis for setting targets to increase agroforestry as part of net zero ambitions and other related climate policy objectives.

Key elements of the methodology are set out in the table, below:

Table 5

System	Description	Mean carbon sequestration per hectare	Impact on food productivity
Silvopasture system	400 stems per hectare –	16 t CO_2e ha^{-1} yr^{-1} over 40 years	Maintaining around half the level of grass production over 40 years
Shelterbelts	6 m wide including 3 m tree row	6 – 8 t CO_2e ha^{-1} yr^{-1} over 40 years	
Hedgerows	2 m wide including 1.5 m wide hedge	6 – 8 t CO_2e ha^{-1} yr^{-1} over 40 years	
Silvoarable systems	150 stems per hectare	8.3 t CO_2e ha^{-1} yr^{-1} over 30 years	Maintaining 74% of crop production over 30 years

Objectives for agroforestry

The Government should make clear the contribution it anticipates agroforestry will make to its legal targets for addressing climate change and fostering nature recovery in England with the aim to:

- balance carbon flows in the agriculture and LULUCF sectors by 2040
- contribute to agriculture and LULUCF sectors reaching net zero by 2050 (accounting for all emissions from land management over the period from 2022)
- use agroforestry to contribute to the creation of the equivalent of 417,000 hectares of new nature rich habitat by 2050.

Setting targets to increase agroforestry

Based on the methodology developed by Cranfield University and to achieve the above objectives, the Woodland Trust recommends the following targets be set:

- 10% of land suitable for cropping should be converted to silvoarable systems as part of a 40-year rotation. This would require 16,131 hectares to be converted each year.
- New hedge and shelterbelt systems should be established on a minimum of 11% of arable land. This would have the potential to create the equivalent of 417,000 hectares of new nature-rich habitat while minimising impacts on food production. Such a move is estimated to be equivalent to replacing all trees outside woods lost on arable land since 1850s (based on an assumption that losses in the Eastern Claylands is typical) – 65 million new trees.
- Combined, the two proposals above would be enough to bring arable land into a carbon balance and be in line with net zero objectives.
- Establish silvopastoral systems on 30% of England's grasslands. This would bring pastoral systems into net zero GHG production by 2051 (assuming no emissions cuts from other farm operations) and would require the establishment

of silvopastoral agroforestry on 81,805ha pa and reduce livestock production by 14% (within the long-term trend for reduced meat production in the UK[1]).

- Update statistics on the length and condition of hedgerows in England with a view to increasing the length standing at 4-5 metres to improve habitat and provide a one-off carbon sequestration benefit of 5.1 tonnes of carbon per hectares (5.1 t CO_2 ha^{-1} yr^{-1}).

Supporting agroforestry in Environmental Land Management schemes

ELM should actively support the establishment of more trees on farms and the improved protection and management of existing trees. To achieve this, priorities for ELM should be:

Agroforestry options for all farmers

ELM must set out clear standards for agroforestry projects eligible for support. Alongside standards for farm woodland and hedgerows, a new agroforestry standard should be flexible enough to take in the full range of agroforestry approaches and to be accessible to all farmers. It should enable and support farmers to:

- identify the trees and woody shrubs assets already in situ and their ecological condition
- understand their potential contribution to both farm productivity and ecological services
- set management actions to maximise biodiversity and carbon benefits of existing and new woody assets
- specify only UK sourced and grown trees and shrubs should be applicable in the delivery of the standard to improve tree health/reduce tree disease risk
- encourage planting a diverse range of native species
- consider improving the hedgerow standard to encourage height above 2m and expanding it to incorporate elements of boundary agroforestry for example optimal shelter belts (5m width)
- access high quality advice, training and guidance.

Land management plans (see below) can play an important role in guiding the deployment of agroforestry through ELM and reduce the risk of the unintended consequence of planting in inappropriate places.

Simple silvopasture and silvoarable systems.
HELEN CHESSHIRE/WTML

[1] https://theconversation.com/meat-eating-drops-by-17-over-a-decade-in-the-uk-new-research-168626

Sheep grazing in parkland.

TIM SCRIVENER

Agroforestry and nature recovery

Government must make explicit the direct link between ELMS and the development and implementation of the Local Nature Recovery Strategies (LNRS).

Farm trees are central to this, supporting productivity, resilience and nature recovery across the landscape. By mapping the location of existing farm trees, the potential for improved habitat connectivity and buffering of ancient woodland and long-established woodland can be identified.

To support this, a minimum requirement of ELM should be to:

- ensure agroforestry is appropriately incentivised in priority locations identified in the LNRS
- include agroforestry options designed to deliver more diverse and complex schemes such as restoration and expansion of wood pasture, large scale silvopastoral schemes and boundary agroforestry schemes
- specify UK sourced and grown trees.

This quality approach will require one-to-one advice utilising evidence from a Land Management Plan and local priorities including those set out in the LNRS maps.

Beef cattle grazing in parkland.

TIM SCRIVENER

Agroforestry at landscape scale

Working at the landscape scale, trees can make an important contribution to nature and climate friendly productive farming in both upland and lowland areas. In intensively farmed landscapes, where land use is less likely to be formally designated for nature, trees in field boundaries can add significantly to nature resilience, water management and soil quality. The need for nature recovery in such environments, and the role of trees in helping deliver it, need to be fully reflected in ELM's support for landscape projects.

Extensive wood pasture support nature recovery.

PETE LEESON/WTML

Tackling barriers to agroforestry

As highlighted earlier in the report, knowledge and expertise in the practice of agroforestry is very low among UK farmers. This will need to be addressed to support large-scale take-up.

Clearer regulation: to encourage take-up of agroforestry, an updated approach to regulation is needed. This should include:

- new, specific, written guidance for farmers and land managers, on how the main types of agroforestry are regulated, such as:
  - when and how forestry EIA and felling licences apply
  - how existing unconditional felling licences (where there is no requirement to restock) can be used (directed by clear policy direction and EIA regulation)
- proper resourcing of the forestry EIA process to ensure all stages of decision making are timely and that the burden of responsibility does not fall onerously on the applicant.

A one-stop-shop for guidance: Currently, regulation and advice on agroforestry is shared between Forestry Commission and Natural England (Forestry Commission is responsible for shelterbelts and riparian planting, while Natural England leads on silvoarable, silvopastoral, wood pasture and parkland and hedgerows systems under agricultural regulation). This risks a lack of clarity on responsibilities both real and perceived. To address this, the following actions are needed:

- a review of protection and regulation of trees outside woods to ensure policy and its implementation are fit for purpose
- designation of a single agency to lead on agroforestry with a remit covering all trees outside woods.

Smart approach to tenancies: trees are, by their nature, a long-term consideration. Tenant farmers are often therefore unable or unwilling to include agroforestry in their land management because it does not naturally fit with the terms of their tenancy agreement. To help overcome this, government should:

- incentivise landlords to include the implementation and management of agroforestry in tenancy agreements
- develop specific agroforestry grants for tenant farmers to address the risk associated with long-term investment.

Further research

Although an overall benefit of agroforestry to nature is clear, significant further research is needed to better understand the relationship. Evidence for some of the key agroforestry systems is lacking and there are numerous knowledge gaps on agroforestry and its impacts. To deepen our knowledge and understanding, and to allow better targeted agroforestry interventions there are a number of areas which should be priorities for further research, including,

- the effects of agroforestry on ground flora
- the effects on mammals, reptiles and amphibians, and microorganisms
- the long-term consequences on understory diversity and how to maintain floristic diversity over time
- how to maximise the benefits of agroforestry in silvopasture
- the benefits of woody landscape features such as hedgerow networks, shelterbelts, and riparian buffers
- the factors limiting the uptake and survival of traditional rural skills such as coppicing and hedgerow laying.

Delivery

Flexibility in scheme design is important to ensure it can be adapted to local conditions, avoids unintended consequences, and maximises biodiversity and carbon benefits.

A land use framework for England

Nature recovery, net zero, climate adaptation, food and energy security all mean major land use change will be needed over the coming decades. While not a magic wand, a spatial framework is needed to manage trade-offs between different land use objectives.

For agroforestry, the framework should help guide the different types of agroforestry to the locations where they can be most effective in integrating different land use needs. For example, shelterbelts and field boundaries are likely to be the best option on highly productive arable land which currently performs badly for nature.

Land Management Plans

Agroforestry's inclusion in ELM would be greatly enhanced by Land Management Plans. Plans can help assess and manage energy use, nutrient inputs and potentially even carbon flows. They would allow a baseline assessment of all natural habitats including trees and woods for each farm or holding and support meaningful monitoring of condition, ecosystem services generated and value for money.

Land Management Plans and agroforestry

How Land Management Plans can support agroforestry:

- Assess and map extent and condition of tree and scrub cover and their ecosystem services.
- Identify actions and incentives to maintain and improve existing agroforestry resources.
- Identify and map opportunities for agroforestry expansion to include:
  - single, clumps and alleys of in-field trees
  - boundary agroforestry (hedgerows/shelter belts)
  - large scale creation and restoration of wood pasture
  - natural colonisation.
- Identify where other actions may be necessary, for example deer and squirrel control.

Advice and training

Agroforestry is a long-term investment. Many of the benefits to both land manager and wider society can take decades to develop. However, with few farms in England currently incorporating trees into their regimes, the skills needed to plan and manage agroforestry are in short supply. This is likely to hinder take-up and risks poor practice.

The provision of good quality advice and training is essential for agroforestry to become a mainstream land use. Achieving this requires the following initiatives:

A skills strategy for trees and forestry

The tree and forestry sector is facing a recognised and significant skills shortage. As efforts to increase tree cover in the UK ramp up, this problem is becoming more acute. Action to respond to the specific skills needs of agroforestry should be a core part of the Government's action to address this problem.

As recommended by the House of Commons Environment Select Committee, a dedicated cross-departmental approach should be established with input from Defra, the Department for Education, forestry sector and training providers including land based agricultural colleges. These groups should be tasked with developing and delivering a clear plan to address the skills shortage in the tree and forestry sector and ensure farm advice is able to include informed guidance on agroforestry as a matter of course.

Sharing lessons learnt from an agroforestry trial at Allerton Project.

HELEN CHESSHIRE/WTML

A peer-to-peer advice network

Defra should coordinate the establishment of an agroforestry peer-to-peer advice network. Acting as a living resource for farmers considering adopting agroforestry, the network would offer online and in-person guidance on agroforestry from those already practising it. As the network grows, it would:

- demonstrate and promote practical agroforestry practice across the full range of land-uses and approaches
- target funding and investment, building on Defra's successful agroforestry ELM Test and Trial
- become a testbed for further research into agroforestry including ecosystem services
- directly support farmers already practicing agroforestry by offering payments for active demonstration farms.

Tree sourcing/availability of saplings

The increase in tree planting is already putting strains on the tree procurement supply chain. Defra should continue to invest in UK grown stock to help fulfil the increased supply with domestic saplings.

Effective funding and financing

Biodiversity Net Gain and ELM funding are priority schemes to deliver the trees element of the LNRS.

Grant incentives through ELM

All ELM schemes should give strong policy support for agroforestry (see above). This must be matched with targeted grant payments that reflect the long-term investment required in order to overcome inertia among land managers, guide efficient land-use and provide for effective management of new and existing agroforestry.

This requires:

- Payment for establishment and management of new agroforestry – existing grant support for trees concentrates on establishment costs. To help ensure that new schemes are successful and that benefits from public investment are maximised, it should be matched with long-term maintenance payments based on the delivery of public goods.
- Grant support to protect and manage existing on-farm trees – agroforestry schemes should include maintenance payments to improve the management of existing agroforestry schemes and mature trees which can form an important part of new agroforestry projects, but which are currently not eligible for support.
- Ring-fenced support – there is significant interest in agroforestry among land managers. For this to generate actual schemes on the ground requires a long-term commitment to funding. Levels of financial support for trees established via the Nature for Climate Fund should be ring-fenced for the first five years of ELM.

Supporting new markets – carbon

Supporting insetting partnerships

The Government should support 'insetting' to help farmers and food businesses work together to reduce GHG emissions. As a counterpoint to the more limited 'offsetting', 'insetting' focuses on emissions within supply chains, sharing the benefits of emissions reduction between land-manager and business and can more accurately reflect progress toward net zero.

As part of a whole-farm approach, agroforestry can play an important role by increasing on-farm carbon storage alongside low carbon farming practices and other initiatives. BEIS and Defra should encourage insetting by setting standards and guidance encouraging the development partnerships between land managers and food production businesses.

The Government should assist this process by providing support for all farm businesses to measure and understand their GHG emissions.

Developing carbon markets for agroforestry

Agroforestry's carbon sequestration benefits do not fit coherently within existing frameworks for calculating carbon units. The Government should address this by testing and deploying alternative options with the appropriate resulting methodology integrated into ELM. This work should consider options such as:

- an expanded Woodland Carbon Code (WCC) capable of taking in both tree and soil carbon associated with agroforestry
- a standalone Agroforestry Carbon Code combining relevant elements of the WCC with the Peatland Carbon Code and proposed codes for soil and hedgerows
- including agroforestry as part of an integrated farm or landscape-scale model assessing overall carbon storage of land-use decisions.

Other markets

There are other market-based approaches which could provide investment for agroforestry projects. These include:

- Biodiversity Net Gain and habitat banking – a requirement for the creation of compensatory habitats to offset those lost to development is expected to form part of the land use planning system
- water management – strategically placed agroforestry projects can help manage water flows, contributing to schemes designed to reduce flood risk in winter and drought in summer

- nutrient trading – trees can be used to help manage nutrient levels in one part of a catchment in order to help ensure the impacts of new development do not breach legal safeguards.

These approaches have the potential to support beneficial agroforestry projects and, by allowing the stacking of benefits, ensure projects combine biodiversity, carbon and other outcomes.

However, they must not be used to justify developments with impacts which would otherwise be unacceptable. A robust evidence base and policy framework is needed to underpin the use of these markets. This is needed to ensure additionality and minimise the risk of questionable outcomes such as the establishment of new woodland to replace high quality wooded habitats which may take many decades to develop.

Innovation funding

Some types of agroforestry bring new agricultural products to the market – for example, fruit, nuts, timber or wood fuel. While this can add to the potential financial viability of projects, the quantities of produce generated is likely to be small.

The Government should expand its innovation funding to:

- carry out regional assessments of the physical infrastructure needed to bring new agroforestry produce to markets
- provide capital allowances for investment in agroforestry infrastructure
- provide innovation funding for collaborative arrangements for capital items and marketing.

Fruit production in a silvoarable system.

TOM STATTON

Silvopoultry at The Lakes Free Range Egg Company.

JONNY WALTON/WTML

WOODLAND TRUST

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