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# Policy recommendations for increasing ecosystem services from trees in agricultural landscapes

# EXECUTIVE SUMMARY

Trees provide a wide range of benefits for agriculture and farmers, with the potential to increase economic returns and support agricultural resilience. Planting more trees on farms can address multiple policy goals, including the UK's aim to become carbon neutral by 2050 and the overhaul of the UK agricultural policies to a better, fairer and sustainable farming system.

This policy brief summarises the current evidence base around tree planting on agricultural land, outlining the positive and negative impacts different tree-planting interventions can have for different stakeholders. We highlight that the net benefit of tree-planting schemes will depend on the planting scheme, agricultural system, scale of implementation and landscape context. To increase the uptake and positive environmental impact of tree planting on agricultural land in the UK, the following challenges should be addressed:

- Support farmer decision making
- Increase empirical evidence
- Provide concrete funding opportunities through the Environmental Land Management Scheme

## TREES ON FARMS CAN PROVIDE MULTIPLE BENEFITS

It is recognised that trees within agricultural landscapes deliver many of the ecosystem services associated with trees and woodland, while at the same time increasing the sustainability and resilience of agriculture (FAO, 2013; FAO, 2020). Trees in agricultural landscapes can contribute to carbon storage, flood mitigation, soil erosion management, water quality, air quality, thermal comfort, biodiversity and health and wellbeing (see Appendix 1). The increased complexity of agroforestry systems compared to agricultural systems alone may even increase yield and promote more resilient systems, in terms of agricultural markets and environmental conditions.

## PLANTING MORE TREES ON FARMS CAN ADDRESS MULTIPLE POLICY GOALS

The UK government's 25 Year Environment Plan aims to achieve climate resilience and net zero carbon emissions by 2050 and includes an ambition to plant 11 million trees by 2042. Given that 71% of land in the UK is agricultural (Defra, 2019), and that 42% of farmers rely on agricultural subsidies to make a profit (Defra, 2018b), it is very likely that farmland will need to host a substantial portion of these 11 million trees (Parliamentary Office of Science and Technology, 2021).

As part of the post-Brexit overhaul of UK agricultural policy, the Department for Environment, Food and Rural Affairs (Defra) is developing the Environmental Land Management Scheme (ELMS), a mechanism to reward farmers with "public funds for public goods" (Defra 2018a). ELMS will deliver environmental benefits through paying farmers for delivering ecosystem services related to climate change and resilience, water quality, air quality, plant vitality and biodiversity, environmental protection, and cultural and social benefits. Trees in agricultural landscapes can contribute to each of these ecosystem services, making tree planting and tree conservation key targets for ELMS.

## CHOOSING THE RIGHT INTERVENTION FOR THE LOCAL CONTEXT

While there is broad agreement that incorporating trees on farms provides the potential for net positive benefits on ecosystem service provision and farm productivity (Parliamentary Office of Science and Technology, 2021; Kay et al., 2019; de Jalon et al., 2018), there is considerable variation in the exact impact of individual planting schemes. In addition to the type of tree planting, net benefits are determined by the agricultural system, intervention scale and landscape context. A lack of UK-specific evidence has been identified by farmers themselves as a barrier to planting trees (Raskin, 2020), despite the fact that the UK has been recognised as a hotspot of agroforestry research (Fagerholm et al., 2016).

To identify whether and how to plant trees, farmers should consider both the potential benefits to their farm (including potential ELMS payments) and the potential challenges they may face, in light of their specific farming and landscape context. Given the long-term nature of tree growth, it is vital that farmers are enabled to undertake well-informed cost-benefit analyses and make decisions based on the best available evidence on their benefits and interventions, before undertaking tree planting schemes. However, currently, there is a lack of simple and direct information that farmers can use to support such land management decision making (Tosh, 2021).

## BENEFITS OF TREES ON FARMS VARY BY PLANTING APPROACH

Trees on farms can be implemented using many different approaches with associated differences in impacts on agriculture and the environment. The most commonly used methods of trees on farms are:

- Linear features: includes hedgerows, shelterbelts and riparian buffer strips - trees grown along field edges
- Silvoarable or alley cropping, agricultural or horticultural crops are grown in alternate strips with a long-term tree crop
- Silvopasture: livestock pasture with trees deliberately introduced to the system
- Groups of trees: clusters of trees within or adjacent to agricultural land, of areas up to 0.1 ha

Appendix 2 provides a detailed summary of the potential benefits and challenges of these four tree planting interventions and how each one of them meet the ELMS targets mentioned in the previous section.

# POLICY RECOMMENDATIONS TO INCREASE UPTAKE OF TREES ON FARMS

Trees on farms can provide multiple benefits for farms, farmers, the public and the environment. The timescales for changes to the financial support given to UK farmers, as well as the imminent and existing challenges brought by climate change, makes it vital that farmers and land managers can be supported in making the right decisions, while delivering public money for public goods. To increase the uptake and positive environmental impact of tree planting on agricultural land in the UK, the following challenges should be addressed:

**Supporting farmers to make informed decisions about tree-planting opportunities available to them through:**

**i. Provisioning basic training to farmers on the potential benefits of trees on farms.** This could include on soil health, land management and tree interventions. Training has direct and multiple benefits by enabling farmers to understand and manage their lands

**ii. Developing standardised monitoring and reporting methods that can support farmers.** This would allow basic aspects of ecosystem services that trees provide to be readily measured, considered and reported on by farmers. Having a central, open-access database would allow learning across stakeholder groups, supporting community knowledge, and gather more UK-relevant evidence

**iii. Promoting effective dialogue between different stakeholders** (farmers, land managers, foresters, policy-makers, researchers and agricultural advisors) to allow cross-fertilisation of ideas and knowledge exchange, building knowledge and confidence. Regional workshops (i.e. Box 2), exploring opportunities for linking existing forestry and agriculture training courses are some examples

**iv. Creating mechanisms to promote tree planting decisions** according to local and regional settings and priorities, so that benefits to farmers, environment, the economy and the public are maximised and trade-offs balanced

**Increase empirical data from UK farms to support farmers and farm advisors in making locally-appropriate, evidence-based decisions through:**

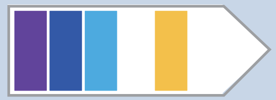
**v. Encouraging the co-creation of research programmes between farmers and research institutions** that include farmer stakeholders as citizen scientists, as involving farmers provides evidence-based advice, facilitates their empowerment, and consequently acting as a sustainable roadmap towards leadership for climate-resilient farms

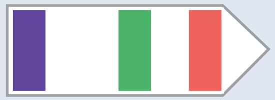
**vi. Providing research funds to cover knowledge gaps** within the UK that reflect the long-term nature of tree research and growth; alongside continued funding for monitoring of existing sites to understand longer-term trends

And it is key to make acknowledgement within SFI and ELMS of the different tree interventions applicable to farms, raising awareness as well as encouraging and supporting best practices. SFI within the ELMS has the potential to support farmers in moving towards more sustainable farming practices (Appendix 1). Creating knowledge and increasing evidence, supporting farmers through training and funding opportunities are key to a better, fairer and sustainable farming system.

# APPENDIX 1

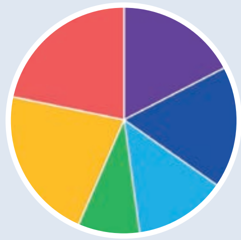
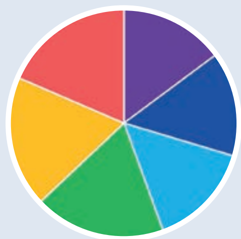
**Expanded Table 1, where the ecosystem services of each tree can be found against the benefits they provide for farms, the environment, the economy, as well as the disadvantages. The interlinkages with ELMS are also highlighted (where each coloured square indicates the ELMS target on public goods shown in page 3: climate change and resilience, water quality, air quality, plant vitality and biodiversity, environmental protection, and cultural and social benefits).**

| ECOSYSTEM SERVICE OF TREES | MECHANISMS OF TREES | BENEFITS FOR FARMS | BENEFITS FOR THE ENVIRONMENT | BENEFITS FOR THE ECONOMY | DISADVANTAGES AND CHALLENGES | INTERLINKAGES WITH ELMS TARGETS |
|---|---|---|---|---|---|---|
| Carbon storage | Trees capture and store carbon from the atmosphere (in relation to speed of growth) | Carbon stored in leaves becomes the perfect supplement for soil. Leaf litter (from fallen leaves) improves soil quality, increasing nutrient content, and porosity facilitating water infiltration, preventing run-off. Leaf litter and tree exudates become a safe storage of carbon above and below ground (increasing average soil carbon in ca. 15% in European soils (Shi et al., 2018) | Trees decrease local atmospheric $CO_2$, which is a powerful greenhouse gas. The decrease of greenhouse gases supports preventing temperature rise and further climate change | Carbon storage directly decreases the impact and dimension of climate change, facilitating economic security. Enhancing carbon storage in all our landscapes, including farm land, supports this mission | Accurately quantifying carbon stored in farmland trees is challenging. Data demonstrating benefits of carbon storage in the UK is scarce (Wolton et al., 2014), and even showing no improvement on carbon storage (Ford et al., 2019). Currently it is uncertain whether soil carbon levels would increase to that of a local woodland (Upson, 2014) |  |
| Flood mitigation | Trees intercept rainfall with their total leaf area and improve infiltration into soils, and take up water from the soil, reducing flood risk | Decrease on flooding secures crop health, improving soil health and therefore improving yield | Prevention of flooding supports retaining carbon and nutrient storage in farmland soil as well as preventing the run-off of chemicals used in farming practices towards water courses | Trees on farms may directly benefit the increase of economic income by providing soil security and crop safety | Trees require abundant water for survival, they can deplete water to crops |  |
| Soil erosion management | Trees capture rainfall with leaves, and therefore reduce run-off of nutrients and sediment on agricultural land. They also reduce the impact of wind and keeping soil structure with their roots (Wolton et al., 2014) | Maintaining nutrients and organic matter within the farmlands is key for efficient yield | Erosion management by trees secures soil biodiversity and safeguards adjacent areas from potential chemical run-off, and preserves carbon storage | By preventing soil erosion, trees support maximizing energies funnelled towards providing the best soil quality for improved yield | Roots may cause lateral damage in land |  |
| Water quality | Trees planted along watercourses can improve bank stability and therefore safeguard watercourses through uptake of excess nutrients (de Jalon et al., 2018) and prevent soil erosion | By maintaining bank stability, farms can secure they workable area at the same time than ensuring water availability for animals and cultivation | Similarly to flood management and erosion management, by supporting water quality, trees support biodiversity in farms, in this case, of freshwater courses | | Trees, depending on species and quantity, may deplete surrounding areas by capturing water for sustenance |  |

| ECOSYSTEM SERVICE OF TREES | MECHANISMS OF TREES | BENEFITS FOR FARMS | BENEFITS FOR THE ENVIRONMENT | BENEFITS FOR THE ECONOMY | DISADVANTAGES AND CHALLENGES | INTERLINKAGES WITH ELMS TARGETS |
|---|---|---|---|---|---|---|
| Air quality | Trees can absorb airborne pollutants (including from livestock and dust) and prevent drift of agrochemical sprays | Prevents cross contamination of airborne pollutants within the farm and to adjacent areas | Limiting the cross-contamination of airborne pollutants safeguards human and animal health | Limiting airborne pollutants decreases diseases such as respiratory concerns and pests and therefore release funding used to fight those challenges | |  |
| Thermal comfort | Trees cool the air in the immediate surrounding area by providing shade and evapotranspiration. They can also create a microclimate during winter | The thermal comfort by trees can protect crops and animals within the farm | The support towards preventing extreme temperatures in their immediate surrounding supports climate resilience | It enhances animal welfare and crop security at all seasons for better yield | Trees may increase night-time air temperatures because tree canopy can trap long-wave radiation in the atmosphere under the canopy (Ziter et al. 2019) |  |
| Biodiversity | Woodland creation increases habitat, structural and species diversity, creating small refugia and corridors or stepping-stones of woodland-like habitat (Torralba et al., 2016; Marsden et al., 2020, Varah et al., 2020) | Attraction of biodiversity provides benefits such as pollination, natural pest controllers and enhancing soil fertility | Given that we are currently under a biodiversity crisis, largely caused by the loss of natural habitat, it is of key importance that habitats within farms are created and restored using trees, forming corridors that will connect the biodiversity network at large geographical scale | Increasing biodiversity may attract natural pest controllers, which support crop security and therefore yield | There is conflicting evidence with regards to the species benefited (Boinot et al., 2019, Fuentes-Mayor et al., 2015), minimal benefits seen, or even not benefit (Mupepele et al., in press). Woodlands can also attract weeds, pests and pathogens. Also, abundance and diversity of pollinating insects, is sparse, and studies often fail to link this to farmer-relevant metrics (exceptions seen: Varah et al., 2020, Staton et al., 2019) |  |
| Health and wellbeing | Trees can promote human health and wellbeing through recreation | Specially for those farms where there is human labour, trees will provide increased wellbeing | | Trees can increase attractiveness and therefore provide opportunities for new revenues such as 'pick your own' produce and leisure. Also, by providing better working conditions, farmers will get benefits to labour from supporting their employees | |  |
| Yield | Trees can protect crops and livestock from extremes of weather and wind, facilitating growth and welfare | Trees provide comprehensive support to farmlands, therefore, securing a positive and long-term farm yield produce | By protecting farmlands in all the above-mentioned aspects, trees support yield production at the same time than decreasing human intervention and supporting wildlife | Trees on farms may support an improved yield production, and therefore support economic growth | There are frequent differences in findings on yield (Pent et al., 2016), or even no significant difference (Torralba et al., 2016) due to the presence of trees in farms. Also, competition for water can reduce crop yields and tree growth (Wolton et al., 2014; Burgess et al., 2005) | Yield indirectly links to supporting all the targets set up by the ELMS |

# APPENDIX 2

**Methods of incorporating trees in farms, their characteristics, benefits, disadvantages and how they meet the aims of ELMS (pie chart: slices are proportional to the estimated ranked value of each ELMS focus area: climate change and resilience, water quality, air quality, plant vitality and biodiversity, environmental protection, and cultural and social benefits).**

| INTERVENTION | CHARACTERISTICS | BENEFITS FOR FARMS AND FARMERS | DISADVANTAGES FOR FARM AND FARMERS | CONTRIBUTION TO PUBLIC GOODS | DIRECTLY MEETS ELM TARGETS |
|---|---|---|---|---|---|
| Shelterbelts, hedgerows | Shelterbelts are tree plantations established to protect crops and livestock from the wind and reduce soil erosion<br>Hedgerows are boundaries planted with trees and shrubs that are over 20m long and less than 5m wide. They have been systematically removed from the British landscape to facilitate the use of farm machinery | • Protect crops or livestock from wind and extremes of temperature (Coed Cymru, 2016; Cornelis and Gabriels, 2005, Palmer et al., 1997)<br>• Provide habitat for pollinators and predators of pest species. (Holland et al. 2017)<br>• Provide favourable microclimate which benefits displacement of livestock and therefore reducing tillage costs (Coed Cymru, 2016) | • Competition with crops or pasture for light, water and nutrients<br>• Provide habitat for crop pests such as woodpigeons | • Carbon storage in tree (including roots) and soil (Wolton et al., 2014)<br>• Prevent soil erosion, protecting soil itself and water quality (Knox et al., 2015, Wolton et al., 2014)<br>• Decrease flood risk / severity through increased infiltration rates (Wolton et al., 2014)<br>• Provide stepping stones / corridors to connect biodiversity across landscapes. (Palmer et al., 1997) |  |
| Alley cropping and silvopasture | Alley cropping are widely spaced tree lines intercropped with traditional crops<br>Silvopasture, are when livestock are grazed under trees. These are two of the most common agroforestry systems in Europe | • There is limited research converging the benefits of these tree interventions in the UK and proving little benefit of this practices.<br>• Source of pollinator systems and pest control (acting as a biological control)<br>• Overall productivity of the agroforestry system is higher than when the components are grown separately (Mosquera-Losada et al., 2009) | • Potential lack of integration of the multiple benefits within farms (Nworji, 2017)<br>• Competition for resources between newly established trees and traditional pasture plants (McAdam and McEvoy, 2009, Nworji, 2017)<br>• Poor performance of trees planted in agroforestry systems and yield reduction that overall does not compensate economically. (de Jalón et al., 2018, Oosterbaan and Kuiters, 2009)<br>• Overall, reduced profitability of agroforestry compared to traditional agricultural systems (alley cropping system shows marginal higher profitability than a pure popular forestry system) (de Jalón et al., 2018; Nworji, 2017) | • Potential increased carbon storage capacity by silvopasture, but not proven for alley cropping (Upson, 2014)<br>• Alley cropping may reduce nitrogen leakage by up taking nutrients, making it more viable than monocultures (de Jalón et al., 2018)<br>• Both interventions may support species within the farms and facilitate movement across the wider landscape, therefore increasing overall biodiversity (Varah et al., 2020) |  |
| Farm woodland and cluster of trees | Both interventions involve planting trees to create small woodlands on farms<br>Both interventions require excluding agricultural activity from the area planted | • Revenue from farming and costs of woodland creation exceed the value of timber production (Bell and Greaves, 2010)<br>• Woodlands can boost pollination, given the right conditions of flowering timing (early) and location<br>• Woodland edges can be an important source of insect predators, and thus potential to reduce pressures from insect pests | • Woodlands have significant potential to act as a source of weeds (Rey Benayas et al., 2008)<br>• Also, woodland edge habitats can support a high density of woodpigeon nests, a major pest on seed crops (Inglis et al., 1994)<br>• The foregone revenue from farming and costs of woodland creation may exceed the value of timber possible production | • Woodland creation for carbon sequestration is a major government goal (DEFRA, 2018a), enhanced in the long-term by a hands-off approach (Morison et al., 2012)<br>• In lowland areas in Britain, afforestation may result in lower carbon loss and thus greater net gain than planting in the uplands (Morison et al., 2012)<br>• Positive biodiversity impacts of woodland creation (Morison et al., 2012) may not be immediate and static, but change over time as the woodland matures (Mallinger et al., 2016) |  |

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