grow Green

Alternatives to Commercial Grazing

A guide for farmers in an age of climate emergency and public goods

Jenny Hall

Foreword

The Vegan Society commissioned this report as part of our ongoing work to support a transition to plant-based agriculture through our Grow Green campaign. It is written as a practical overview and starting point for farmers and landowners who wish to explore new alternatives and it was partly prompted by enquiries that we have received from farmers themselves over the past few years.

British farmers take great pride in their produce and the vital service they provide to the public. But the needs of society, public attitudes, and the UK's priorities when it comes to land use are changing. The effects of climate change are being felt across the world and as progress is made in reducing emissions in the energy sector, there is greater attention on the critical role of food and farming in responding to the climate crisis.

Changing public priorities are reflected in planned changes to the structure of farming subsidies in the UK. The Environmental Land Management scheme is due to begin in 2024 and will replace the Basic Payment Scheme which is due to be phased out between 2021 to 2028. This change, alongside other new funding streams, could enable the introduction of a greater variety of climate and nature friendly land management practices, and rural businesses must be supported to take advantage of this opportunity.

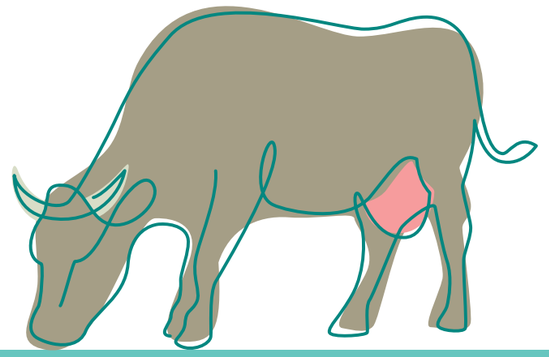
Achieving sustainable land management in the UK will mean big changes across many different types of agricultural production. This guide focuses on alternative land management options to commercial grazing on marginal land.

For a long time, the default has been to use land that is not suitable for arable crops as pasture for farmed animals. This has been supported by area-based payments to subsidise farm income. While there is sound ecological reasoning to ensure grazing animals remain part of our landscape, the vast area currently given over to grazing in the UK severely limits the scope for long term carbon sequestration and habitat restoration, as well as other productive land uses that should form part of a low carbon economy.

Our soils and vegetation have huge capacity to draw carbon out of the atmosphere, offsetting emissions from other sectors and enabling the UK to meet its climate objectives. Farmers and land managers will also be vital in achieving other important objectives such as biodiversity conservation and reducing flooding.

Land management is a hugely complex issue and to make progress it is crucial that we engage openly and honestly with the range of different beliefs about the future of agriculture in the UK, especially with farmers and those who are directly responsible for managing our land. I hope this report will prompt more imaginative and productive conversations about the future of the UK landscape and our relationship with it.

Tim Thorpe, The Vegan Society



About the Author

Jenny's earliest memories are of her grandparents' hill farm in the Forest of Bowland, Yorkshire. It started her lifelong interest in farming systems. It was meeting leading lights of the Organic Growers Alliance, Alan and Debra Schofield, in 1997, that changed her life and got her on the path of becoming a land manager. Jenny worked in various roles including setting up a box scheme from scratch which is now run in several counties. Very much influenced by fellow organic grower Iain Tolhurst, in 2005 she co-wrote the vegetable farmer's textbook "*Growing Green: Organic Techniques for a Sustainable Future.*" The book is sold internationally.

In 2009 Jenny co-founded Climate Friendly Food CIC. She has trained new entrant organic vegetable farmers working in both the North West and South East. In 2011 she wrote the think-piece "Market Garden Britain 2030" to lay out the possible social, health and environmental benefits including the belief that moving towards a nine-a-day model from home-grown produce could enable a massive reduction in greenhouse gases. These preliminary findings have been backed by later academic research.

Jenny runs a small working farm (which includes a market garden and commercial forest garden) with her two daughters with the Liverpool-based Organic Direct Box Scheme. She is also a trustee of an international charity and works part-time for Lancashire Wildlife Trust on their wetlands project.

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Disclaimer

This document is about opening up conversations on commercial grazing alternatives, and looks towards solutions which promote net-zero-carbon, nature-recovery and the zero-waste circular economy.

It gives an overview of some possible land management options and provides links to detailed resources where these are available. The references and resources referred to in the document contain ideas and schools of thought that may not necessarily represent the views of The Vegan Society.

Because of the focus of the report, it does not address ethical issues around the treatment of animals as 'products'. The Vegan Society wishes to see an end to all animal exploitation, and as non-human animals are sentient beings with their own inherent value, we do not support the use of terms like 'livestock', or any other description that objectifies non-human animals. However, these terms are commonplace in agriculture and in order to make this report legible to non-vegan audiences, use of such terms has been necessary in places.

No guarantee or warranty is made, expressed or implied concerning income generation or crop performance as a result of using this guide.

All income and expenditure costings are within four years of 2020 and outgoings are based on standard contracting costs.[1] The figures quoted should be seen as broad indicators of trends since income and expenditure will vary significantly between farms.

Definitions

Marginal land is classed as that which is not ordinarily used for arable purposes. This is traditionally agricultural classifications Grade 3b, 4 and 5 and land slopes above a 15-degree gradient.

Peatland is classed as both upland and lowland and denotes soils that are organic (as opposed to mineral) in composition.

Farmer is a proxy for land manager and can include multigenerational family farmers, estate owners, tenant farmers, smallholders and community organisations.

Carbon sinks refers to the drawing down of atmospheric carbon dioxide into a terrestrial form usually locked in the soil. It is sometimes referred to as carbon capture or carbon sequestration.

Carbon store refers to holding carbon in the soil but not drawing down fresh new carbon each year. Grassland and forestry tend to reach a state of equilibrium from a 50–100 year time frame from the point of land-use change.

Chapter 1
Introducing the guide for farmers and land managers

The alternatives to commercial grazing can be broadly summed up as a movement towards carbon sinks and nature recovery of agricultural land on marginal and peat soils.

1.1 Policy drivers

We cannot allow climate harm to worsen. If it does, in the UK we will lose land as the sea level rises. We will also experience more frequent extreme weather including regular flooding and extreme heat. Globally, climate harm will make it too hot to produce food in many parts of the global south, and will lead to mass movements of dispossessed peoples.
We cannot allow biodiversity loss to get worse, since numbers of the UK's most important wildlife have plummeted by an average of 60% since the 1970s.[2] The 2015 Paris Agreement[3] unites all the world's nations in a single agreement on tackling climate change for the first time in history.

One important challenge is that natural biological cycles, despite their enormous value to people, are hard to make a financial profit from. "Public money for public goods" should help to end this cycle and enable farmers to stop using environmentally damaging practices, preserving our natural resources for generations to come.

This guide was created to address the demand of some farmers who are looking for environmentally beneficial alternatives to farming animals, without necessarily giving up farming. This will be made more possible with new legislation, (at the time of writing the Agriculture Bill (2019) and Environment Bill (2019) are going through Parliament).

Over the next 30 years farming will be expected to achieve:

- ***Net-zero-carbon***, meaning the UK-wide economy will not emit more carbon dioxide equivalents (CO2e) than it draws down. This requires carbon sinks (e.g. peat bogs, woodland and soil carbon), embodied carbon (e.g. timber in buildings), renewable energy (replacing fossil fuels) and keeping fossil fuels in the ground.
- ***A nature recovery network*** of restored peatlands, wetlands, wildflower meadows, wood-pasture and woodlands.
- ***A circular, zero-waste economy*** which phases out fossil fuels, other mined minerals and substances that cannot be broken down by natural processes, such as plastics.

The market will not achieve net-zero-carbon nor nature recovery by itself, and farmers need to be paid in the form of public money for public goods, charitable giving and/or corporate social responsibility (wherein, for example, a company pays to offset its carbon emissions).

Table 1: 16 alternative income streams to commercial grazing on marginal and peat lands

Put up a fence as a herbivore exclosure, and let nature recover (whilst removing invasive species) for nature recovery funding
Restore upland blanket bog for carbon credits and water catchment credits
Restore lowland raised bog restoration for carbon credits
Grow sphagnum moss for horticulture using paludiculture
Grow typha (cattails) and phragmites (reeds) for thatching and insulation boards
Plant broadleaved woodland for carbon credits
Allow natural succession with herbivore exclosure of ravines linked to carbon credits and water catchment credits
Grow hedges linked to carbon credits
Licence beaver reintroduction linked to water catchment credits
Grow standard timber and nursery trees linked to carbon credits
Grow sweet chestnut or hazel coppice for fencing and carbon credits
Grow biomass for renewable energy, pulp and chip (willow and miscanthus)
Cut hay from wildflower meadows for "dry anaerobic digestion" using decentralised CHP
Grow vegetables on favourable grade 3b land
Grow orchards and commercial forest garden fruits linked to carbon credits
Grow alleys of trees with edible fruits and nuts linked to carbon credits

The supply-side farming management options already exist. Growing perennial plants, rewetting peatlands and reintroducing flora and fauna are tried and tested techniques with high skill sets within the conservation NGOs and conservation charity sectors. Farmers will benefit from this collective knowledge.

1.2: Understanding nature recovery

The government's Lawton Review in 'Making Space for Nature'[4] found that nature reserves on their own are not enough. Nature recovery networks need to be bigger, better and more joined up. The Lawton Review discussed "wildlife corridors" and "stepping stones" linking nature reserves (featuring wildlife-friendly hedges and ponds, for example) with "buffer zones".

The term "rewilding" has become a political hot potato and is likely to provoke lively debate. Rewilding advocate Professor Alistair Driver argues that the "nature reserve approach" has not halted the decline of biodiversity. He states that we need large-scale conversion including interventions with lower management costs.[5]

Professor Dieter Helm, Chair of the Natural Capital Committee, criticises aspects of rewilding[6] and warns that there is an illusion that at some point in the past there was a "natural nirvana." According to this critique, rewilding ignores the intractable issues such as the need to accommodate nearly 70 million people, and invasive species causing loss of habitat for native wildlife. Also, which point in the past do you choose? Rewilders seem to prefer when the wildwood[7] was tamed during the modern stone age era (although Frans Vera suggests it was already a "half-open landscape").[8] Going back even further in time, to 115,000 years ago before the present, there were straight tusked-elephants[9] large enough to push over trees and shrubs. It could be argued that large elephants may prove better eco-system engineers than cows, ponies, sheep and boars but no one is suggesting they should be reintroduced.

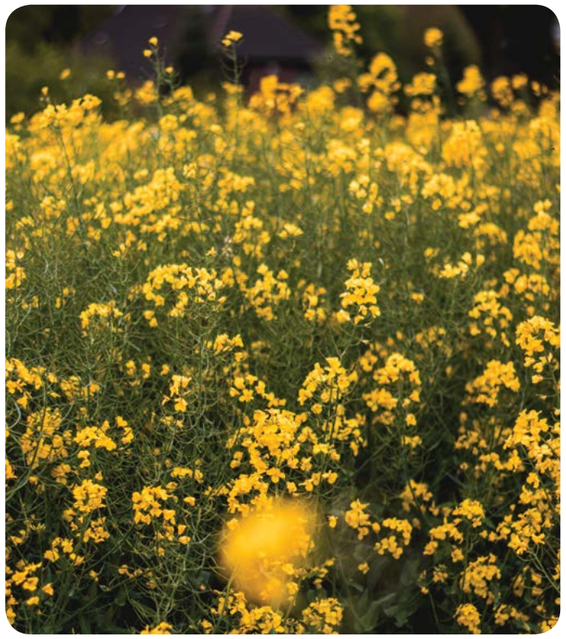
Restoration needs public support, subsidies and grants. Nature recovery must not be seen as just a "nice to have" in the economy since we need to have natural capital to pass on to the next generation.
When large-scale conversion of land to carbon sinks and nature recovery is successful, it may be possible to reintroduce key stone species and gain special status because of the wildlife contained within. Reintroducing species back to the wild has captured public imagination. These can be humble, such as the reintroduction of the peat-bog-loving large heath butterfly at Astley Moss near Manchester after being extinct in the UK for 150 years.[10]

The white-tailed eagle project in Mull, Scotland,[11] offers strong evidence that the reintroduction of a charismatic species can be a driving force in UK rural economies, in this case bringing £5 million per annum to the local economy. Similarly, wolf reintroduction in Yellowstone National Park, USA and wild lynx, wolf and brown bear populations in the Carpathian Mountains, Romania have enabled these areas to become popular ecotourism destinations. The Committee on Climate Change's calls for nearly a quarter of agricultural land to go into long-term carbon sinks certainly strengthens the case for charismatic reintroductions in the longer term, this aim does not appear to be compatible with current levels of livestock farming.

1.3: Plant-based agriculture affords space for nature recovery

Simon Fairlie's Can Britain Feed Itself? shows that plant-based agriculture (whether agrochemical, organic or permaculture) with home-grown wholefoods affords the most space for nature recovery over all other farming systems in the UK.[12] When you model a healthy diet alongside rising populations and the carrying capacity of the environment, the main recommendation is always eating more whole plant-based foods. For example, The Eat-Lancet report[13] summarises the challenge: *"Transformation to healthy diets by 2050 will require substantial dietary shifts. Global consumption of fruits, vegetables, nuts and legumes will have to double, and consumption of foods such as red meat and sugar will have to be reduced by more than 50%. A diet rich in plant-based foods and with fewer animal source foods confers both improved health and environmental benefits."*

Arable land needs to move towards crops for direct human consumption on the principle of "people nourished per



hectare" (see 8.1). This will involve the ending of producing feed grains and biofuels on arable land and growing some vegetables and fruits on grade 3 marginal land. It is important to imagine a diet that is not dependent on hidden overseas inputs like soya and palm, largely fed to farmed animals. A home-grown diet would see everyday imports becoming more of a seasonal treat. This would be especially true with salad vegetables or soft fruits.

This guidance does not abandon grazing altogether, and there is a discussion about the role of grazing animals in nature recovery. However, grazing herbivores that support conservation land management do not need to be part of food production and can include wild, semi-wild, companion and sanctuary animals.

To enable this, the government should ensure that ELMs supports for conservation grazing for nature recovery alone?

1.4: Net-zero-carbon target

The net-zero-carbon target by 2050 will require substantial changes in farming and land use. Farming is uniquely positioned to create more carbon sinks and will be relied upon to offset emissions in other parts of the economy. Similar patterns are happening in other countries because of the 2015 Paris Agreement.[14] The Treaty unites all the world's nations in a single agreement on tackling climate change for the first time in history.

The Committee on Climate Change (CCC) are a government advisory body who have broadly laid out the management options for net-zero-carbon target. Their panel includes the National Farmers Union (NFU) and Country Landowners Association (CLA). Alternative but similar scenarios are presented by Zero Carbon Britain (ZCB) from the Centre of Alternative Technology, who have been analysing the problem since 2007.

The CCC 2020 report entitled 'Land use: Policies for a Net Zero UK' focuses on policies to change practices on 22% of land into long-term carbon sinks. According to CCC further intensification of agriculture is not acceptable.

As the carbon sinks and nature recovery will be largely on marginal land, which has low calorific food output per hectare, it should avoid further food imports that risk "carbon leakage". The CCC stresses that "carbon leakage" must be avoided.
CCC recommendations for net-zero-carbon (with higher ambitions) include:

- Restoring between 50%–75% of upland peat and 25%–50% of lowland peat by 2050 (similar large scale rewettings are happening in other countries[15])
- 30,000–50,000 hectares of new woodland each year (increasing forestry cover from 13% up to 19%). Tree planting should be avoided on UK Biodiversity Action Plan (BAP) priority habitats, land with cultural value and peatlands
- 23,000 hectares of new perennial bioenergy crops each year
- Dietary change from between 20%–50% shift away from the most carbon-intensive foods of beef, lamb and dairy
- Reducing 13.6 million tonnes of food waste annually by 20%
- Better soil and livestock management practices

Table 2: Committee of Climate Change Carbon Dioxide Equivalent savings from different land use scenarios

According to the CCC, "better soil and livestock management"

Recommendation	Million tonnes CO2e
Better soil and livestock management	9
New woodland and hedgerows	8 - 18
Peatland restoration	4 - 11
Bioenergy crops with carbon capture	2
Totals (Mt CO2e / yr)	**23 - 40**

involves precision fertilisers, acidification of slurry and improving farm animal health. This scenario is unambitious with regards to soil health, the soil-food-web (being the foundation of all terrestrial food chains) and a movement away from fossil-fuel based fertilisers and pesticides.

In their 2019 report Achieving Net Zero, Farming's 2040 Goal the National Farmers Union (NFU) called for similar overall carbon savings as outlined by the CCC in Table 1. However, the NFU has gone further in its calls for soil carbon sinks and bioenergy.

The other major difference between CCC and NFU is bioenergy crops. These should not be on arable land as this pushes food production abroad and causes "carbon leakage". The bioenergy debate is discussed in 7.7.

All three bodies of work (CCC, ZCB, NFU) show a direction of improvement. This guide outlines the management options to enable it to happen, using case studies where possible.

More carbon sinks, drawing down atmospheric carbon dioxide, in turn help nature to recover.

This guide outlines management options for soil carbon sinks:

- Designating land for wildlife especially with natural succession in chapter 3
- Grazing lands with wood-pasture in section 4.3
- Peatland restoration and paludiculture in chapters 5 and 6
- New woodlands, hedges and coppice in chapter 7
- Ending agrochemicals on cultivated soils and replacing with green manures and woodchip in rotation in section 8.1
- Orchards, commercial forest gardening and alley cropping of trees in agroforestry in 8.3

***1.4:** Economic analysis of net-zero-carbon farming*

Vivid Economics, on behalf of the CCC, have undertaken a detailed economic analysis.

Figure 1: Benefits to the UK economy by a movement towards net-zero-carbon land-use[16]

Note: All estimates in present value terms, discounted at the UK social rate. Source: Vivid economics.

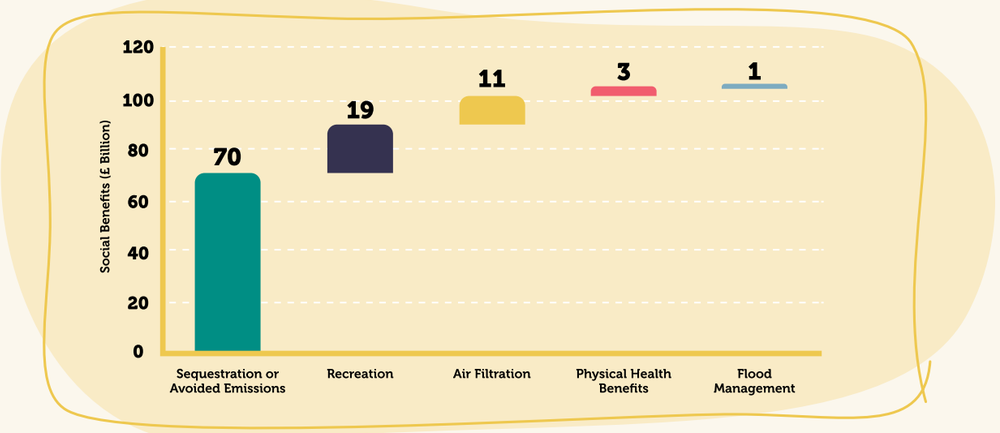
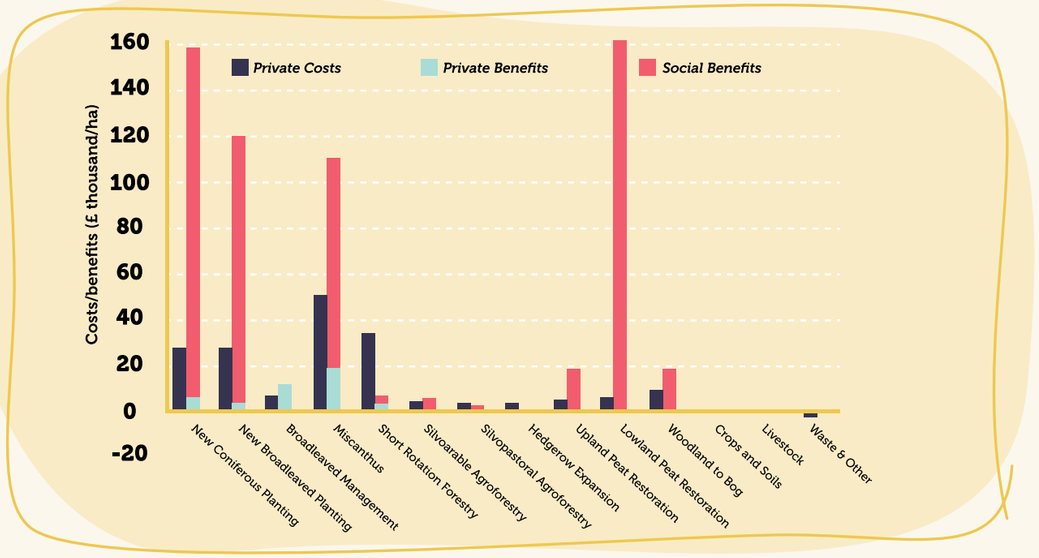


Figure 2: Farmer costs (dark blue), farmer income (light blue) and public goods (pink)

Note: All estimates in present value terms, discounted at the UK social rate. Short rotation coppice costs and benefits are not included in this diagram. Social costs per hectare are £132,000. Source: Vivid economics.



This bar chart enables farmers to look at the management options at a glance. The navy blue bar represents the costs a farmer would be expected to bear if there were no grants compared to the light blue bar of the income they would receive solely from the market. The pink represents the "public good" the farmer provides to society.

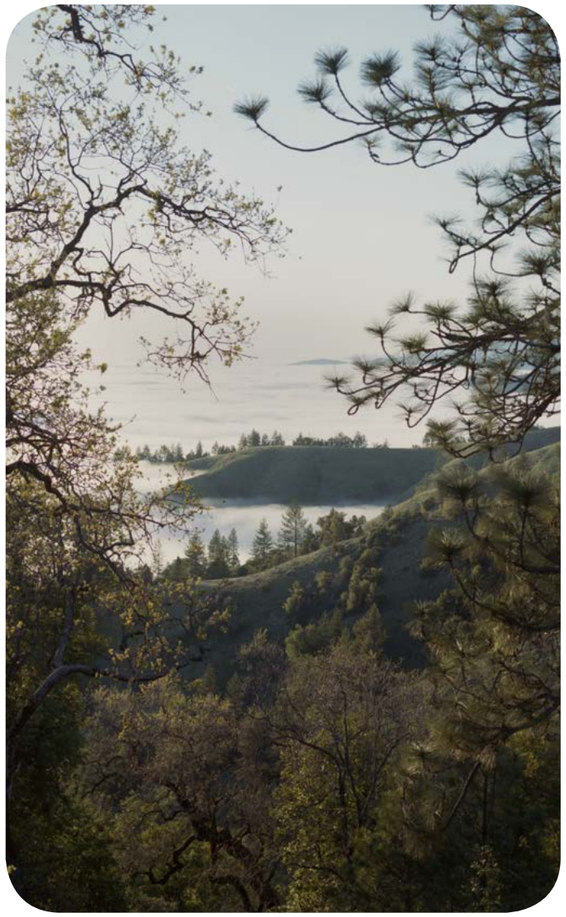
This chart shows why the farmer cannot be expected to bear the cost of net-zero-carbon. The private benefits do not cover the private costs. New woodland planting and peatland restoration have the highest social benefit-cost ratio and need to be pursued as a matter of priority if the UK is to reach its carbon reduction targets under the Paris Agreement.

Farmers on marginal land and peat lands will be at the forefront of a once-in-a-generation opportunity to shape future farming policy to adopt climate and wildlife-friendly land management. This will mean treating carbon sinks and nature recovery as valuable outcomes alongside conventional agricultural goods.

Chapter 2
Government funding for farmers is moving towards "public goods"

This chapter examines the government funding opportunities available to farmers. These relate to the idea of public goods which are defined in the 25 Year Environment Plan.[17]

Public goods include clean air; clean and plentiful water; thriving plants and wildlife; a reduced risk of harm from environmental hazards such as flooding and drought; using resources from nature more sustainably and efficiently; enhanced beauty, heritage and engagement with the natural environment; mitigating and adapting to climate change; minimising waste; managing exposure to chemicals and enhancing biosecurity.
The language of public goods originates from economics and is used to describe resources that are available for everyone to access and are necessary for our society to operate in a more sustainable way. Private funding opportunities for carbon offsetting in relation to peatlands are discussed in 5.2 and in relation to woodlands in 7.1.



2.1: Grants administered by the Rural Payments Agency

The UK treasury has pledged the same expenditure as was available under the EU Common Agricultural Policy (CAP) until the end of Parliament (likely Winter 2024). The Basic Payment Scheme (BPS), based on land area, will be phased out from 2021 with reductions in higher payment bands initially. There will also be a "de-linking." This is a term used in DEFRA to show that grants will be offered without the requirement to farm the land, a previous requirement of the CAP. DEFRA acknowledge that this may mean some farmers decide to retire.[18]

Grant payments will move to towards public money for public goods. The Environmental Land Management (ELM) scheme will begin with a pilot starting from 2021 and will be rolled out across England in 2024.[19] It is still fluid and will not be defined until after the pilots, although many farmers hope it will not be as paperwork heavy as the Countryside Stewardship Scheme.[20] DEFRA have released some information:

- **Tier one** will encourage farmers to adopt environmentally sustainable farming and forestry practices that can be effective if done across the UK e.g. rotations, overwinter green manures, wildflower margins and riparian buffer zones.
- **Tier two** will be locally targeted outcomes similar to Higher Level Stewardship e.g. maintenance of existing priority habitats and land-use change.
- **Tier three** will involve landscape scale land-use change e.g. restoring peatland.

Although the ELM itself is likely to be more generous than its predecessor, it is unlikely to cover the loss of BPS. Average farm incomes and profitability are likely to be significantly affected. Strutt and Parker (2019) have undertaken an analysis (see 2.4 resources). It will be important to keep up to date with this information in the farming press.

2.2: Other public goods around Natural Capital

Natural Capital Schemes include Nature Recovery Networks linked to Nature-based-interventions.
The underlying idea around nature recovery is discussed in 1.2 and can be summarised as the need for nature to be "bigger, better and more joined up"[21] . When it comes to climate mitigation, nature based interventions cost a fraction of engineered solutions, like direct air capture of carbon or low-carbon concrete. They are not just about carbon but are valuable also to other parts of environmental net gain, especially pollution removal.
An environmental census of natural capital across England (Wales, Scotland and Northern Ireland have their own arrangements) is required alongside the mapping[22] of the potential land for woodlands or peat bog restoration.

It may be possible for farmers to be ahead of the game by early involvement with the Nature Recovery Networks which are likely to start in 2021.

Regional Environment Funds, with several local authorities grouping together, may invest in climate interventions and reduce the risk to farmers. For example, at the Greater Manchester Natural Capital Conference 2020,[23] stakeholders expressed a keenness for more demonstration projects that would allow learning and knowledge transfer between farmers. Further schemes involve the Environment Agency looking at waterway catchment solutions and property developers becoming locked into a system of environmental net gain through the planning system. This will encourage private and public investment in trading carbon credits and providing ecosystem services.
By pursuing a policy of environmental net gain other public goods will be achieved:

Thriving plants and wildlife: woodlands, wood-pasture, hedgerows, wildflower meadows, reverse of 'insectageddon',[24] earthworms and other soil wildlife as the foundation of all terrestrial food chains, opportunities for modest reintroductions of keystone species (eagles, beavers and pine martens), peat bogs with their rare flora and fauna (reintroducing large heath butterfly and carnivorous plants like sundews and bladderworts).

- **Clean and plentiful water:** wetlands with their reedbeds as natural filters, improved water absorbency in the uplands, eroded peat particles no longer having to be removed from drinking water.
- **Clean air:** fewer wildfires when blanket and raised bogs are rewet, less fossil fuel use and less reliance on imports.
- **Reducing the risk of harm:** increased vegetable, fruit and nut growing; more opportunities for wholefoods plant-based diets taking pressure off the NHS, reduction in flooding for downstream communities, reduction in zoonosis viruses.
- **Beauty, heritage and engagement:** increased recreation boosting eco-tourism.

2.3: Away from fossil fuels

Administered by the Department for Business, Energy & Industrial Strategy (BEIS) is the Smart Export Guarantee (SEG) to support solar photovoltaic, hydro, micro-combined heat and power (with an electrical capacity of 50kW or less), onshore wind and anaerobic digestion. However, this grant scheme is not as generous as former schemes as there is no revenue for generation alone. Farm investment in renewable energy has dropped dramatically. It will be important to keep up to date with this information in the energy press.

2.4: Resources

https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk

https://www.cat.org.uk/info-resources/zero-carbon-britain

Economic impacts of Net Zero land use scenarios

https://rural.struttandparker.com/article/the-future-farming-funding-gap-paper-2

Tree Suitability Modelling – Planting Opportunities for Sessile Oak and Sitka Spruce in Wales in a Changing Climate

https://energysavingtrust.org.uk

Chapter 3
Land for wildlife

Nature recovery is set to provide awe-inspiring life experiences for farmers and their communities. As humans we are hard-wired to experience the wellbeing that the natural world has to offer. This guide proceeds on the notion that 'self-willed' nature recovery and nature recovery with human intervention are both valid. What is more important is that nature recovery is happening since biodiversity loss cannot afford to wait. Nature recovery and rewilding are discussed in 1.2.

Dunsany Nature Reserve

Randal Plunkett, Lord of Dunsany, Co. Meath, Ireland describes his journey towards creating a nature reserve. He has given 750 acres of the 1600 acre estate over to the Dunsany Nature Reserve, some of which was in existing woodland. Randal is from a line of innovators, with Horace Plunkett founding the Plunkett Foundation in 1919 which supports community businesses in rural settings across the UK and Ireland to this day.

I inherited the estate in 2011 and initially began organic livestock farming. However, that was a financial disaster for me. At first I thought that "organic" would be sufficient as I could not bear the poisoning of the land with agrochemicals. However, I remember the dehorning of the bullocks as a particularly shocking experience. As land managers we are driven to overdo everything and we are constantly taking. I wanted to stop this and move towards a model of "replenishing".

I was born with privilege and within my family there is a sense of duty to give back. My ancestors may have been able to assist in the past with building schools, for example. Then it came to me that the one place where I can make a big difference is the environment. At this time, I also decided to become vegan. Helping the environment is also helping people. It is important to see the earth in the big sense. If you want to change the world you start with your own patch.

At the time of conversion, I had never heard the term "rewilding" and described it more as "nature preservation." It wasn't my role to tamper. Nature needs the opportunity to take its original path through a course of self-fulfillment without interference. So, for example, if we do release any animals at Dunsany they have to be native wildlife. Also, because of wanting such radical change, I did not want to be locked into the subsidy system where the project could be changed because of the need to jump to a funder's agenda. I have to pay three staff and so have rented out the arable parts of the estate to do that. I will, however, look to woodland grants in the future.

I should state that I have no interest in ecotourism but understand why others would want to generate income off visitors. There are no footpaths and whenever people go in, they follow the deer tracks. The challenges we face are largely around stopping poaching from the land. The first few years of the project required me to hold my nerve; there was ragwort everywhere and thistles in the spots where livestock had poached the land. However, four years on and they have gone since unhealthy soils leads to excessive weeds. It is incredible. Nature does the work itself. I love to see the tree saplings self-generating.

I think there needs to an active process of promoting natural decay. We have mature woodlands and we are keen when timber is removed that some remains for wildlife. This approach means we have overcome historical tree diseases on the site. Natural flooding and wetlands lead to more life. Flowering plants on the regenerating grasslands are really important, especially for the insects, and again I see it as the idea of "replenishing". Nowadays if you drive near the estate you are certainly getting insects splatting on your windscreen and other people have started to notice. I estimate there is twenty per cent more wildlife each and every year.

I am learning wildlife ID and have an app on my phone to help me. I remember recounting to a wildlife expert who was walking with me that I would love to see a snipe, which were here in the 1950s. And there, on cue, it appeared in a corner where natural flooding has started to take place. Other returns include woodpeckers, hares, otters and pine martens. Buzzards are not just occasional visitors now – they are constantly flying overhead. Trinity College, Dublin are starting to show an interest in our project from a botanical and wildlife perspective.

Nature preservation is a lot less effort than organic livestock farming, and much more rewarding. Controlling nature is a paradox. It requires more and more effort. Nature preservation does not meet a business model, but that is not to say that you should not monetise what you have. I believe we are at the last station with climate and biodiversity and now is the time to act. Wilderness, at a deep level, feels the right thing to do. To my knowledge, Dunsany nature reserve is the biggest rewilding project in Ireland, and I look forward to more following suit in the future.

Land for Wildlife

Public Goods	Does this contribute?
Carbon Sink	Yes
Fossil Fuel Replacement	Potentially fuel wood from coppice and brash removal
CO2 emissions offset	Yes
Nature recovery	Yes
Water Catchment	Yes
Eco Tourism	Yes
Credit Schemes	Carbon sink, CO2e offset, flood alleviation
Livelihood without subsidy	Possibly if there is a visitor experience

Income opportunity, costs and risks

Setting up a nature reserve and ending animal farming on all or part of your farm is not an easy decision. The starting point is to seek professional advice from either a formal advisor (like English Nature, Scottish Natural Heritage, Natural Resources Wales or Northern Ireland Environment Agency) or a wildlife charity like the Wildlife Trusts, RSPB or similar. Conversion considerations warrant a cost-benefit analysis using a business plan approach to see the feasibility of an ELM scheme and/or visitors.

Practical management considerations

A pervasive problem with nature recovery is that "invasive" or "alien" species may dominate. Plant considerations will include rhododendron, giant hogweed, himalyan balsam and Japanese knotweed, all of which can be manually removed. The difficulties arrive when creatures like mink, crayfish, zebra mussels, grey squirrels, pheasants, rabbits and deer dominate the ecosystem so that other biodiversity is wiped out. This is where the arguments for apex predators, as ecosystem engineers, become more persuasive. Large apex predator reintroductions like wolves or lynx are likely to meet opposition from sheep farmers fearing predation. However, other keystone predators like eagles and pine marten may prove less controversial.

Five-year study of Beavers in Devon[25]

Beavers are the ultimate river engineers as they dam rivers by gnawing down trees and saplings. The River Otter Beaver Trial was a five-year project (2015-2020) to investigate the effects of a wild-living population of beavers on the River Otter in Devon.

Photo credit Mike Symes Devon Wildlife Trust

Beavers' quantifiable benefits on the River Otter, including eco-tourism and "ecosystem services" such as flood alleviation, outweighed costs such as the minor flooding of some farmland and damage to riverside trees. However, management of conflicts is shown to be a vital part of their reintroduction. For example, orchards can be protected by wire guards or beaver dams can have pipes through them to reduce water levels (known as "beaver deceivers").

The five-year trial found that the beavers played a significant role in filtering pollutants including sediment and fertilisers from the river, while new wetlands created by the beavers have benefited water voles, riverine birds such as dippers and wildfowl including teal. There were 37% more fish in pools created by beaver dams than in comparable stretches of river. Sea trout have been recorded leaping over beaver dams during high river flows. It can be concluded that beavers have the ability to breathe new life into riverine habitat.

Reintroduction of beavers must be done under licence and there must be no likelihood of them being harmed by dogs.

Chapter 4
Alternative pasture management

Land use change is increasingly seen as an essential part of the UK's climate response. Many farmers with grazing animals on marginal land are looking at ways to diversify or manage land differently. The rest of this guide looks at some options for these land managers, including benefits and risks to consider, with some examples of good practice.

This chapter discusses trends within grazing which do not necessarily represent the views of The Vegan Society. As the objective is habitat management for nature recovery, herbivores in conservation grazing scenarios do not have to be part of the food chain. This could include wild, semi-wild, companion or sanctuary animals.

4.1: Why we need public goods for pasture – decline of soil carbon, flooding, overgrazing, farmer uncertainty

Carbon sinks – Grassland is a carbon store but it is unlikely to be a carbon sink (accumulating new carbon each year). Grassland and forestry reach equilibrium within a 50 to 100-year timeframe from the moment of land-use change.[26]

It is likely that most of the UK's older forests and permanent grasslands are at equilibrium[27] or are possibly even losing soil carbon if they are regularly poached or soil is washed into waterways. It is still important to preserve these carbon stores. However, they are not drawing down carbon dioxide from the atmosphere.[28] The exception to this is wood-pasture, at the point of conversion from solely grassland or tillage, for a period of 50–100 years, discussed in 4.3.

Flooding – Many houses, communal buildings and factories have been built on flood plains. The risk to "floodplain communities" is exacerbated by upstream land management. There is far less water-holding capacity upstream when:

• On mineral soils grass is short, soil is compacted[29] and there is a lack of woody perennial roots including trees.

• On peat soils if woody perennial roots are drying out the blanket bog, if the underlying peat is exposed (peat hags), or if burning occurs.

Changing management of the uplands could provide value to local communities by reducing flood risk. However, upland problems are strongly linked with shooting rights and burning the heather. These are outside the control of the farmer, especially if they are a tenant farmer. This section will, therefore, be valuable to all upland managers.

Our uplands and grasslands need to become more rainwater absorbent.

Business as usual, where uplands are grazed to a few centimetres, is becoming less socially acceptable especially in downstream areas where householders and businesses can no longer obtain house insurance because of regular flooding. It makes sense to prevent flooding before it happens.

Farmer uncertainty

Within the massive shifts in farming there is a lot of uncertainty and worry amongst farmers, some of which is captured in the case study of Bradley Nook Farm.

Bradley Nook Farm, Derbyshire
Jay and Katja Wilde

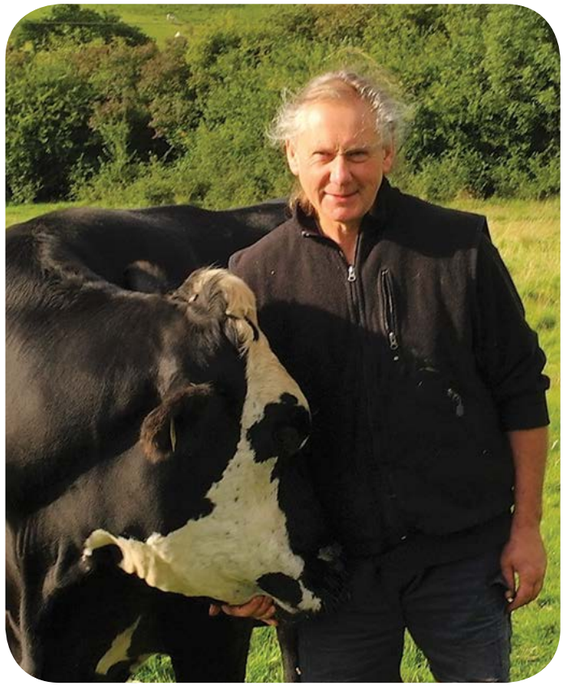


Photo credit - Jay Wilde

We are a medium-size livestock farm with around 70 hectares. We have always found it difficult to send cattle to the abattoir. We decided to approach The Vegan Society for help to change our business to veganic horticulture, with the help of their Grow Green initiative. Being the first farmers to work with them, we had a lot of media attention. Finding a sanctuary that was prepared to accommodate our entire herd immediately meant that we had to rush our planning. This has made our transition somewhat awkward as there are many things to consider.

As the majority of our fields are in RPA Stewardship schemes (either for the protection of rig and furrow, the remnant undulations of historic plough lines in the ground, or for significant numbers of wildflowers in the hay meadows), we had only a small choice of fields to consider for field crops. What we were not aware of is that even the fields not in stewardship are by default protected as 'unimproved grassland', i.e. these fields have not been artificially fertilised nor ploughed for 15+ years. We had to submit an Environmental Impact Report to Natural England about the biodiversity and archaeological features to ask permission to plough, as the area we are hoping to use exceeds 2 ha. As yet, the verdict is out and should permission be refused our field cropping area would have to be reduced to less than 2 ha with no prospect of increasing it at a later date.

We have been thinking of ways to use the hay meadows long term, bearing in mind that they cannot be ploughed. We have looked into anaerobic digestion, extending our sanctuary herd, selling the hay to other sanctuaries within a reasonable distance (although this proved difficult because they have suppliers they will not upset by shopping around), creating compost that we could mix with the muck from the barns or even the potential of mushroom growing. Selling wildflower seeds might also be an option.

The circumstances also rushed our plans for the diversification of the old farm buildings. Ideally we would have had the plans worked out before removing the cattle from the farm. The unfolding uncertainties have much increased the personal impact of the transition.

We have kept 17 of the cows and this really softened the blow. It is a group that we were connected to. They have the same lifestyle as before in that that they are in the shed for the winter and out the rest of the year, keeping the hay meadows in shape. Because the herd is so small now, our interactions are even less rushed and there is the opportunity to get to know them on an even closer level. Another cattle farmer commented that he could feel a very relaxed atmosphere within our little herd and how different it was.

Katja is currently undertaking a commercial organic growers course with a view to setting up a market garden with polytunnels. There is also much potential for rewilding of the wider farm and the eco-tourism that could come with this. One 7 ha field is already returning to a wetland with the collapse of the land drains and Jay loves to watch the owls and curlews that have recently settled here.

4.2: Management option – Conservation grazing densities

Conservation grazing is about prioritising wildlife, with the biodiversity value of grassland as the primary objective. This involves much lower densities of herbivores, and often different hardier breeds like "natives" or "rare breeds." All land that is not suitable for cultivation and has a mineral base may be suitable for conservation grazing (as it would also be for wood-pasture, coppice or woodland). Conservation grazing is a particularly good option with some UK Biodiversity Action Plan (BAP) priority habitats or land with cultural value e.g. ridge and furrow.

Public Goods	Does this contribute?
Carbon sink	No
Fossil fuel replacement	No
CO2 emissions offset	No
Nature recovery	Yes
Water catchment	Yes
Eco-tourism	Yes
Credit schemes	Water Catchment
Livelihood without subsidy	No

Income opportunity, costs and risks

Whilst counter intuitive for some with the withdrawal of BPS it could be that ELM payments for conservation grazing may make more financial sense than incurring the costs associated with meat production. Sheep seem to incur more costs than cattle and are harder to keep healthy.[30] The carrying capacity of land for conservation grazing (see table 2) is very low. The herbivores need access to a large range for year-round grazing. This large range and low stocking density eliminates the expense of supplementary feeding or winter housing (providing they have access to natural outdoor shelter). Further costs can be saved by reducing annual breeding, bedding, forage harvesting, slurry disposal, contractors, plastic silage wrap and medication. There will also be less opportunities for zoonosis transfer which is more likely in enclosed spaces.

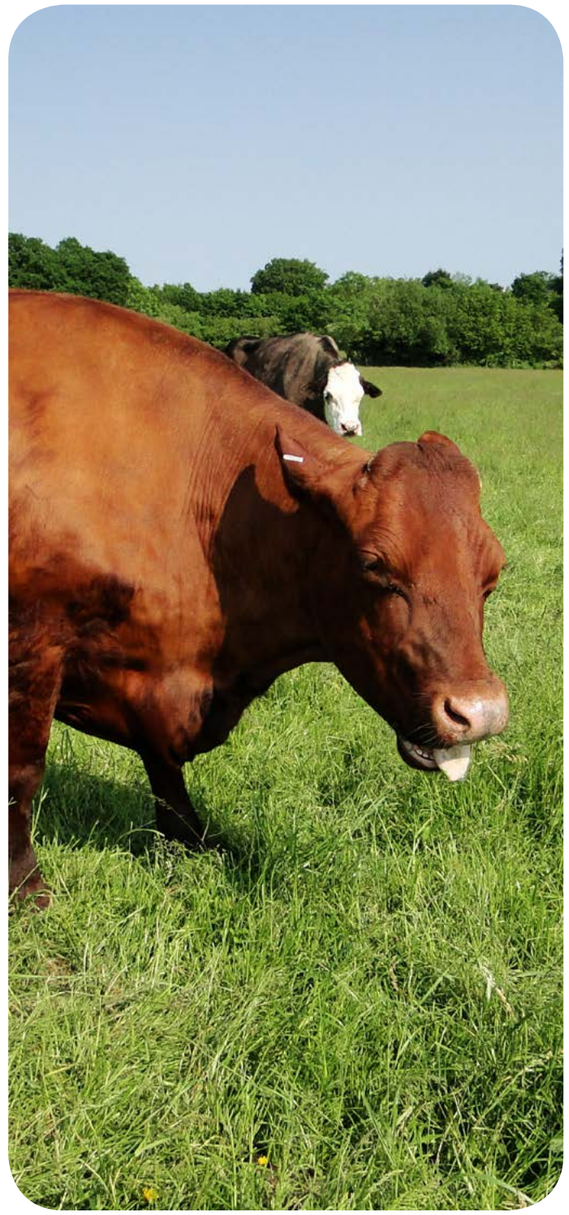


Photo credits - Hugletts Wood Farm Animal Sanctuary

Table 3: Carrying capacity of land for year-round conservation grazing

Land use	National Vegetation Classification	Carrying capacity livestock units[31 32]	Carrying capacity of the land in common language *One cow equivalent per...*
Business as usual (including nitrogen enrichment, concentrates etc) for comparison only	MG6	1.0	1 Hectare
Intact blanket or raised bog	M17, M18, M19	0.02	50 Hectares
Nutrient-poor fen	M4 - M10	0.1	10 Hectares
Upland wood pasture (mineral)		0.14	7 Hectares
Upland purple moor grass (mineral)	U5, M25	0.25	4 Hectares
Upland sheep fescue common bent (mineral)	U4, CG10	0.5	2 Hectares
Lowland wood pasture (mineral)		0.3	3.5 Hectares
Lowland grass pasture (mineral)		0.3 to 0.4	2.9 Hectares
Sphagnum reintroduction	M17, M18, M19	0.0	No grazing – sphagnum forming hummocks cannot be trampled[33]

This table shows the number of large grazing animals that can be supported by different habitats. Cow equivalents are "one cow and youngster" or "one older cow". On upland bogs low-level grazing can assist with the control of moor grass and conifer saplings. This is seen as beneficial before reintroducing sphagnum mosses which are not tolerant to trampling. This is further discussed in 5.2 in relation to blanket bog restoration.

Conservation charities have suggested that ELM payments could have extra financial incentives if results are achieved. For example, the RSPB is currently exploring the potential of a set of bird indicator species for uplands and Less Favoured Areas – corncrake, chough, curlew, lapwing, redshank, twite and whinchat to show whether nature recovery is happening. Basing payments on environmental outcomes has the potential to incentivise farmers to innovate, rather than merely adhere to prescribed practices.[34]

Practical management considerations

When it comes to lowering herbivore densities the most recent schools of thought are:

- **Conservation grazing –** matching herbivore densities to the carrying capacity of the land where nature recovery is the focus (see table 2).
- **Avoid inputs –** The Nethergill Approach[35] to upland farming states that with concentrates, fertilisers and sprays, there is no correlation between variable costs and profitability, so it does not make sense to buy inputs.
- **Plant more trees –** increases in wetter weather are leading to a greater number of problems that need medication e.g. liver fluke in sheep. Farmers are being encouraged to plant trees for animal shelter. Scottish Forestry have created a short film of a farmer's experiences with tree planting.[36]
- **Avoid high herbivore densities –** this typically happens with uncontrolled breeding. The Dutch "Oostvaardersplassen experiment", with its swamp and fen habitat, had too many herbivores. This resulted in all the flora being wiped out, starving herbivores and distress of the people connected to the project.
- **Create wood-pasture –** discussed next.

4.3: Management option – Wood-pasture

On mineral soils, the first 50–100 years of wood-pasture offset more carbon than extensive grassland, but require lower herbivore densities. As a general principle, the fewer the herbivores, the better the carbon sink if natural succession and woody growth are occurring.

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	No
CO2 emissions offset	Potentially
Nature recovery	Yes
Water catchment	Yes
Eco-tourism	Yes
Credit schemes	Carbon sink, C02e offset, water catchment
Livelihood without subsidy	No

Income opportunity, costs and risks

The considerations with wood-pasture are similar to conservation grazing with the exception of allowing self-established woody perennials to grow. These create a mosaic of habitats: with open-grown trees, emerging scrub, grazing lawns, groves and thorny thickets. The Knepp Wildland experiment for wood-pasture has introduced trophic (multi) level biodiversity. The turtle dove has returned alongside insects like the purple emperor butterfly that benefits from scrubby willow.[37]

There is an opportunity for income from the carbon sinks. Standard pricing for wood-pasture carbon credits is yet to happen. The carbon offset and nature recovery aspects under ELM payments could potentially make wood-pasture financially more favourable than grassland alone, especially if linked to a results-based approach to nature recovery (see 4.2). Wood-pasture supports far more priority wildlife than grassland, especially if it has ancient pollarded trees.[38]

Similar to conservation grazing, avoiding the associated costs of meat production and grazing for nature recovery alone may make financial sense (see 4.2). The practice of wood-pasture is likely to involve 88% less herbivores per hectare than business-as-usual farmed grassland.[39]

Herbivores with large ranges, raised on wood-pasture, are likely to have a better diet, walk more freely and therefore will save on medication costs. Herbivores need natural shelter and opportunities for breathing in pollens and eating wild plants for self-medicating purposes. Grassland, even when wildflower-rich, is not as well adapted to supporting herbivores.

Practical management considerations

As internal fences are removed, it could well be that the only significant start-up cost will be the strong outer perimeter fence to keep out other wild animals and access to watering holes especially in times of drought. It is likely that wood-pasture can become a significant ecotourism attraction.

4.4: Management option - Wildflower meadows for hay

The very richest hay meadows contain over 30 species per square metre with up to 120 species per field. The presence of Wood crane's bill is a key indicator that other aspects of nature recovery are happening. The goal is to move meadows towards species-rich classifications within the National Vegetation Classification (NVC). These include:

Dry meadows

- MG3a sweet vernal-grass/wood crane's-bill grassland (soft-brome sub-community)
- MG3b sweet vernal-grass/wood crane's-bill grassland (quaking-grass sub-community)
- MG4 meadow foxtail/great burnet grassland
- MG5a crested dog's-tail/common knapweed grassland (meadow vetchling sub-community)
- MG6+ perennial rye-grass/crested dog's-tail grassland (yellow-rattle sub-community)

Damp meadows

- MG8+ crested dog's-tail/marsh marigold grassland
- MG8n crested dog's-tail/marsh marigold grassland (northern sub-community)
- MG8y crested dog's-tail/marsh marigold grassland (yellow-rattle sub-community)

Public Goods	Does this contribute?
Carbon Sink	No
Fossil Fuel Replacement	No
CO2 emissions offset	No
Nature recovery	Yes. especially bees, butterflies and ground nesting birds
Water Catchment	Potentially
Eco Tourism	Yes
Credit Schemes	Water catchment
Livelihood without subsidy	Potentially if there are sufficient hectares

Income opportunity, costs and risks

Wildflower meadows should attract ELM funding for nature recovery. If the farmer already has the baling equipment, the start-up costs may be very low. Hay yields can vary widely from 4–16 large bales[40] resulting in £120–£480 direct sales based on £30 per bale. Based on topping, raking and baling, the annual costs per hectare are likely to be around £55.[41] When making hay, timing is important as it needs to dry out in the sunshine. It is likely that hay which is sold direct, e.g. to horse liveries, will command a greater return.

Practical management considerations

Initial sowing advice includes scarifying and hand spreading seed or green hay and then trampling it to ensure seed to soil contact. Parasitic flowers like yellow rattle, which will take away the rigour of the grass, can be planted to assist the development of meadows. Hay is made after mid-July through to August to allow the wildflower seeds to drop to the soil. The land is not fertilised to encourage a running down of the nitrogen levels to favour wildflowers. When nitrogen levels reduce and species improve, troublesome weeds (thistle, bracken, dock, ragwort, nettle, buttercup and dock) give away to the more biologically interesting (e.g. lady's mantle, wood anemone, common knapweed, various orchids, ragged robin and adder's tongue).

4.5: Management option - Wildflower biomass for "dry" anaerobic digestion (AD)

Lincolnshire Wildlife Trust have created an FAQ web page based on their own road verge biomass harvesting trials with Lincolnshire County Council and partners. Trials have also been undertaken by Kent County Council and the Kent Wildlife Trust.

Public Goods	Does this contribute?
Carbon sink	No
Fossil fuel replacement	Potentially if harvesting, transport to AD plant and operating AD plant are lower
CO2 emissions offset	Potentially
Nature recovery	Yes especially bees, butterflies and ground nesting birds
Water catchment	Potentially
Eco-tourism	Yes
Credit schemes	Water catchment
Livelihood without subsidy	Potentially depending on arrangement with AD plant

Income opportunity, costs and risks

According to Peakhill Associates Limited,[42] the yield is estimated to be 12.5 fresh weight tonnes per hectare with informal discussions indicating around £15–18 per silage tonne (2019 prices) delivered to the AD plant. This means the typical hectare can yield £188–£225 per hectare with a silage costs of £147 without transport to the AD plant. It means the economics are marginal unless nature recovery is paid for by the ELM scheme. On farm AD with grid-connection is capital intensive and energy subsidies are less generous than they once were (see chapter 2).

Practical management considerations

Wildflower biomass does not lend itself to "wet AD" because it needs to be small in particle size, lush and fresh. The dried flower seed heads of wildflower silage resist immediate bacterial breakdown and dry materials can clog the digestate tanks' stirring motion. The AD plants prefer chopped maize silage but sadly increasing maize cultivation has been a disaster for soil health.[43]

A more likely scenario is wildflower silage generating biomass energy within localised "dry AD plants" which are more suited to this material. These are not widespread in the UK and research is currently being undertaken with the University of Manchester, University of South Hampton, QUBE Renewables and Straw Innovations. The material sits for 28 days without a stirring action. It could well be that the future role of "dry AD" is linked to Combined Heat and Power at a local level or off-grid properties.

The same husbandry advice applies as section 4.4 on wildflower hay.

4.6: Resources

http://www.magnificentmeadows.org.uk/advice-guidance

http://lnp-meadows.nuclnp.org.uk/resources

https://wildseed.co.uk/page/management-of-meadows-and-grassland

https://www.lincstrust.org.uk/wildlife/wildlife-gardening/wildflower-hub/verges-faq

https://www.kentwildlifetrust.org.uk/get-involved/our-projects/grassification

https://www.quberenewables.co.uk/dryqube

Chapter 5
Restoring Peatlands

Peatlands are the most efficient carbon sink on the planet over long-term timeframes. They are the largest terrestrial store of carbon, storing twice as much carbon as forests. Good bog habitat supports globally rare species of plants and animals.

Hummock forming sphagnum mosses are most effective at taking carbon out of the atmosphere and are likely to keep growing in perpetuity. They are immortal plants that are constantly growing from their tip whilst their undergrowth (alongside the other bog vegetation litter) is preserved within the anaerobic conditions of the acidic bog.

The UK is amongst the top ten nations of the world in terms of its total peatland area. The UK has between 9–15% of Europe's peatland area (46,000–77,000 km2) and about 13% of the world's blanket bog – one of the world's rarest habitats. There are three main types of peatland in the UK: blanket bogs, raised bogs and fens.[44] Peatlands have been damaged by mass drainage and extractive practices like peat for garden plants, turf, overgrazing and cultivation.

However, upland management problems are strongly linked with shooting rights and the burning of heather. These are outside the control of upland farmers, especially tenant farmers. This section may be valuable to those interested in upland management more broadly.

5.1: Why we need public goods in the uplands - flooding, emissions, fire and drinking water

Flood risk
Our peatlands must become more rainwater absorbent to help address the flooding and upland management issues discussed in chapter 4.1. Improving management of the uplands to restore peatland has huge potential to reduce flood risk.

Reducing emissions by moving from heather to bog-plants
Heather-dominated peatlands have higher methane and carbon dioxide emissions than those with a predominance of sphagnum or cotton grass.[45]

Fire and drinking water
Heather also increases problems with wildfire. That is not to say that heather does not have a role. For example, cross-leaved heath is important in the lifecycle of the rare large heath butterfly. However, the heather species, with their bog drying roots, will be more at the margins and the specialist wet bog plants should be given the opportunity to flourish. Dominance of sphagnums and cotton grass will reduce the risk of wildfires and improves water holding capacity. Peat erosion is a particular problem for drinking water quality since discolouring particles are carcinogenic and have to be removed.

5.2: Management option – Blanket bog restoration

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	No
CO2 emissions offset	Yes
Nature recovery	Yes
Water catchment	Yes
Eco-tourism	Yes but requires boardwalk to avoid sphagnum trampling
Credit schemes	Carbon sink, CO2e offset, water catchment
Livelihood without subsidy	No

Income opportunity, costs and risks

Peatland restoration of blanket bog is solely a public good for the purpose of nature recovery and carbon sequestration. It is likely to be rewarded within the highest tier of ELM payments. The private "carbon credits" market for peatlands is currently being developed by the International Union for Conservation of Nature (IUCN),[46] although it is not as developed as the woodland code (see 7.1). It is also likely that "blue economy credits," to support water quality, could develop.

Peatland restoration is likely to receive funding through Tier 3 of the ELM scheme which supports landscape scale, land-use change projects. This support will be essential as costs of contractors and machinery can be substantial.

Planting activities may be supported with voluntary help organised through charities like The Wildlife Trusts. The rewetting of peatlands has been one of the easiest ways for countries to achieve their climate commitments under the Paris Agreements. Restoring peatlands may make more financial sense, over sheep farming, when the BPS is withdrawn.

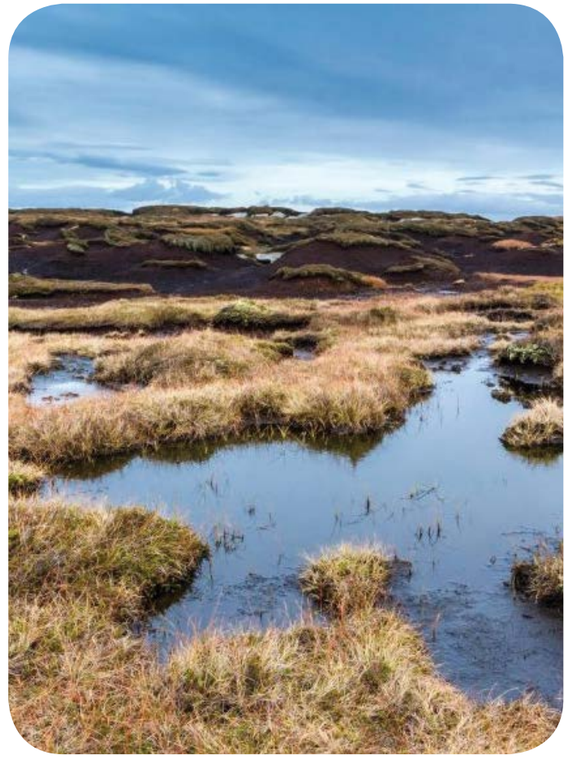
Practical management considerations

Sphagnum moss reintroduction will grow best where there is no grazing or trampling. This requires a fencing "exclosure" of the perimeter boundary to keep out grazing herbivores (e.g. deer, rabbit and hare),geese can also pose a problem, especially with cotton grasses. Fencing can help to avoid damage inflicted by people e.g. using off-road motorbikes. The British Deer Society offer advice around fencing.[47]

On vast tracts of land, reintroductions of apex predators could achieve the same and are aspired to by the rewilding movement (see 1.2).

The peatland will need to be prepared to reintroduce bog plants, especially sphagnum and cotton grasses. The first action is raising the water table. This can be done through grip and gully blocking, heather bale dams, peat dams and bunds, stone dams, plastic piling and timber dams. It is also possible to create "cells" with perimeter bunds to hold the water. The bunds may have drainage pipes between them to keep the peatland moist without becoming a lake. Sluices may also be used. If the land becomes more like a lake it may require pumping water to other areas. The sphagnum mosses cannot tolerate wave ripples. Rewetting often takes several attempts to find all the drainage points.

Once the water-level conditions are correct, the next stage is to introduce cotton grass (common and hare's tail) as plugs or seeds. Once these have taken a hold (possibly from year 2) then it is possible to translocate sphagnum moss either through chopping it up or the use of beads or sphagnum through micro-propagation. A short cut can be introducing sphagnums much earlier under heather brash or straw. During the early years it will be necessary to remove bog drying perennial roots, especially heather and silver birch. Once the bog mosses are established this is a self-perpetuating eco-system with low to zero annual costs.



Plant communities of an active bog

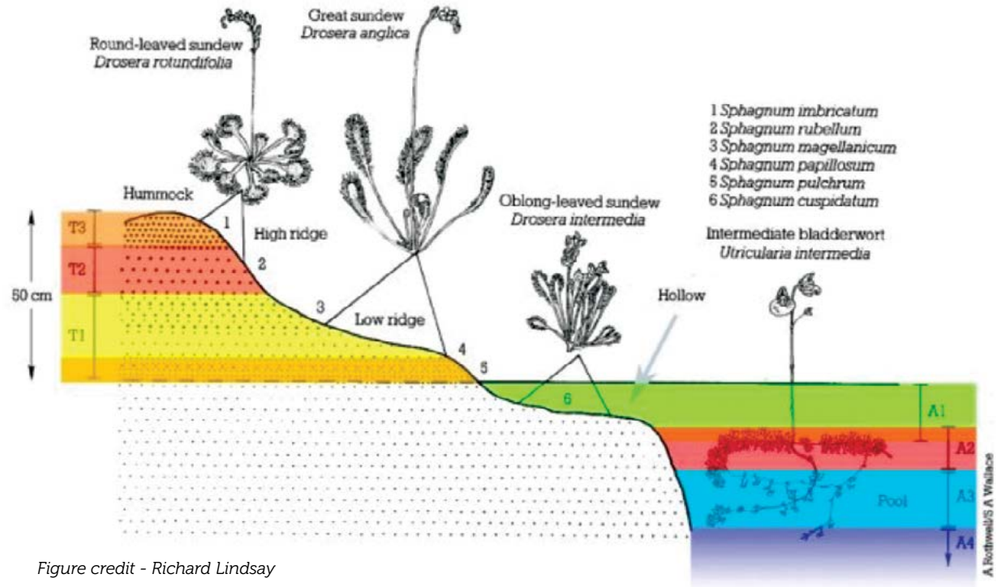


Figure credit - Richard Lindsay

5.3: Why we need public goods in lowlands – Soil subsidence, fertility loss and flooding

If the cultivation of lowland fens and mosslands is continued, with a peat subsidence rate of 1–2cm per year,[48] their oxidisation to the atmosphere is a serious problem for climate harm. A UK government Soil Health Report (2016)[49] advised that soil degradation could result in some of our most productive agricultural land becoming unprofitable within a generation. Carbon loss is not the only problem; mosslands are becoming increasingly difficult to cultivate because of the formation of plate-like aggregates, this means that water cannot soak through. This results in an increased likelihood of flooding; vulnerability to wind erosion; and vulnerability to wild fire.

5.4: Management option: Lowland raised-bog restoration

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	No
CO2 emissions offset	Yes
Nature recovery	Yes
Water catchment	Potentially but not as important as the uplands
Eco-tourism	Yes but requires boardwalk
Credit schemes	Carbon sink, CO2e offset
Livelihood without subsidy	No

Income opportunity, costs and risks

Similar to blanket bog in 5.2, peatland restoration of lowland raised bog is solely a public good for the purpose of nature recovery and carbon storage, and will be reliant on ELM payments and carbon offset schemes. Unlike its upland counterpart, lowland peatlands can generate more income from cultivation but are at greater risk of loss through oxidisation.

Practical management considerations

The practical management considerations are similar to blanket bog and are described in 5.2.

Photo credit - Moors for a Future Partnership

Care-peat Carbon Farming – Lancashire Wildlife Trust

97% of lowland raised bog across Lancashire, Greater Manchester and North Merseyside has been destroyed. Lancashire Wildlife Trust has been at the forefront of restoring peatlands in the area. Trials by Manchester Metropolitan University and BeadaMoss® show that plots on a former peat extraction site in Salford, at Little Woolden Moss, are already capturing carbon.

The rare Large Heath Butterfly photographed at Winmarleigh Moss. Photo credit: Alan Wright for the Lancashire Wildlife Trust.

Care-Peat is a multinational EU-funded Interreg initiative with five pilot sites. The project will share knowledge of best practice.

Project Manager Sarah Johnson from Lancashire Wildlife Trust said, *"We are growing a permanent, non-harvested cover crop of sphagnum grown for the purpose of protecting soil carbon and sequestering further atmospheric carbon on 4 hectares. We will also be assessing the effect of re-wetting this buffer zone area on the adjoining 89 hectares Winmarleigh and Cockerham Moss SSSI nature reserve, which is Lancashire's best example of intact lowland raised bog.*

"We hope to demonstrate the viability of alternative land management techniques on drained peatlands. This will be an important demonstration for farmers in terms of carbon and improvement to the wildlife. However, it will need support from subsidies or carbon offsetting schemes. Our project aims to provide the data needed to be able to devise appropriate funding schemes.

"Initially we will slow the damage, stop the loss and then go on to carbon capture. We know that from elsewhere this can happen in a 2–3 year time period. We had to strip the first ten centimetres because of farming residues like calcium from lime applications and nitrates. The removed peat can help with access paths and bunds. We are experimenting with nutrient load and particularly how this affects weeds. I do like the idea of using a nurse crop like "Typha" (see chapter 6) for removing nutrients. The carbon farm is an intermediary state between farming and nature conservation."

Sphagnum moss can be a harvestable crop, used as an ingredient in growing media for horticultural use. This is discussed in chapter 6 and is promising for income generation to farmers but it comes with potential trade-offs, as harvesting would not have the same value for nature recovery.

5.5: Resources

If you would like an in-depth introduction to the importance of peatlands for carbon by Richard Lindsay (2010) - *www2.rspb.org.uk/images/peatbogs_and_carbon_tcm9-255200.pdf*

The National Committee for the United Kingdom Peatland Programme (IUCN) have briefings - *https://www.iucn-uk-peatlandprogramme.org/peatland-resources/briefings*

Moors the Future Partnership offer practical advice to farmers: *https://www.moorsforthefuture.org.uk/our-resources*

BeadaMoss® products have been developed to reestablish living sphagnum hummocks and sphagnum lawns - *http://www.beadamoss.co.uk/page2.html*

If you have a peatland soil on your farm and would like to consider restoring by raising the water table, there is likely to be a landscape peatland partnership near you to assist. *Peatland Programme Projects Map*

Some of the experienced voices within this field are:

Yorkshire Peat Partnership have a contract to provide advisory services across the UK - *https://www.yppartnership.org.uk/our-services* and are lead partner of the North of England Peat Partnership.

Moors for a Future Partnership (South Pennines) - *www.moorsforthefuture.org.uk*

North Pennines AONB Partnership - *https://www.northpennines.org.uk/what_we_do/peatland-programme*

Cumbria Peat Partnership - Cumbria Wildlife Trust are lead partners - *https://www.cumbriawildlifetrust.org.uk/about*

Welsh Peatlands Sustainable Management Scheme - *IUCN Working together for the future of Welsh peatlands*

Peatland ACTION (Scotland) - *Peatland ACTION - Project resources*

Chapter 6
Promising lowland paludicrops on peatlands

The history of farming is the history of our struggles to tame the bog. We need to reverse this and put the drained peatlands under water again. 'Palus' is Latin for 'swamp', and 'paludiculture' is also known as 'wet agriculture'. This is a form of productive land use that allows degraded peatlands to be taken out of cultivation or pasture and to be rewet. It can then produce "paludicrops" whilst tackling climate harm. Paludiculture can generally only happen where there is machinery access and as such is probably limited to lowlands. Some paludiculture can also be done on constructed wetlands with a mineral soil.

Converting well-drained and fertilized peatlands into paludiculture fields will significantly lower greenhouse gas emissions.[50] Once established, sphagnums will last indefinitely and other paludicrops will last for at least 20 years without losing rigour. Rewetting of land is a significant investment and farmers need to be confident that there is a market for paludicrops. The easiest opportunities for this are on mosslands which have become too wet for farming.

Table 4: Potential paludicrops including foraging

Waterlogged Crops	Sphagnum (peat moss), phragmites (reed), typha (bulrush or cattails), zinania (wild rice), glyceria (sweet grass) edible tubers (sagittaria – duck potato), persicaria hydro piper (water pepper) and medicines (sundews, bog myrtle, bog bean and meadowsweet).
Crops that are flood tolerant but prefer drained & cannot manage constant waterlogging.	Phalaris (reed canary), micanthus (elephant grass), arundo (spanish cane like bamboo), blueberry (vaccinium), salix (willow coppice), black alder (for timber)

Table 5: Potential paludicrops for large-scale conversion

Crop	Ideal Water Table	Products Produced	Incentives	Notes
Lowland bog - nature recovery	2–10cm below the surface	Public Good	Carbon Blue economy	Encouraging diversity
Sphagnum lawns for horticulture substrate	2–10cm below the surface	Extracted peat replacement	Carbon Blue economy	Cannot tolerate mains water
Typha - bulrush, reedmace	0–20cm above the surface	Insulation Bioenergy Textile fibre Plastic substitute	Carbon Blue economy	Peat and mineral soils
Phragmites - common reed	20cm below to 20cm above the surface	Thatching, paper Bioenergy	Carbon Blue economy	Peat and mineral soils
Yellow flag Iris	Not known	Cut flowers	Carbon Blue economy	Peat and mineral soils

The paludicrops in table 5 require a mechanised farming approach. The products that they produce will be increasingly important as we move away from fossil fuel dependent materials (especially building materials and plastics) and fossil-peat in gardening.

6.1: Management option: Husbandry and machinery considerations

All paludicrops will succeed better with:

- "Exclosures" of grazing herbivores.
- A high and controllable water table which should prevent competition from weeds.
- Woody perennials like heathers or tree roots being removed which will dry out the peatland.

Even if the wet conditions can be maintained, nitrogen can become the limiting factor for the non-sphagnum paludicrops, and unwanted algal growth can be a problem for all paludicrops.

The use of heavy machinery increases performance but does not necessarily lead to higher ground pressure when the machinery is equipped with wider tyres or tracks.[51] Machinery can include:

- An adapted farm tractor with flotation wheels or twin tyres with a lightweight baler.
- Small uniaxial tractor with cutter bar.
- Reed harvester with two or three axles and balloon tyres.
- Tracked special machinery which are usually adaptation of snow groomers.
- Crane for sphagnum "grabbing".
- An aspirational "Moor Truck" which is similar to a combined harvester.

6.2: Management option – Sphagnum (Peat Moss) Farming

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	No
CO2 emissions offset	Yes
Nature recovery	Potentially but not as much as peat bogs for their own sake
Water catchment	Potentially but not as important as the uplands
Eco-tourism	No
Credit schemes	Carbon sink, CO2e offset
Livelihood without subsidy	Yes

Income opportunity, costs and risks

Harvested sphagnum lawns can be used as a renewable raw material for horticultural substrates, substituting fossil-peat. A sphagnum farm will look different from a blanket bog or lowland bog restoration, as it will require the entry of machinery and will not be encouraging other bog flora and fauna. Grieswald Mire Centre have looked into a crane arm as sphagnum has zero tolerance for trampling. Sphagnum farming requires initial control of the water levels with drainage blocking techniques similar to upland blanket bog (5.2) and lowland raised bog (5.4) restoration. As sphagnum moss is a valuable crop, it may be beneficial to control water sluices with remote sensors and irrigation equipment to ensure optimal growing conditions.

BeadaMoss® Trails (www.beadamoss.co.uk) suggest the potential is that each hectare should yield between 1500 and 3000 cubic metres of sphagnum, with each cubic metre worth about £30–50. That should make it a viable crop, however, further financial incentives such as carbon offsetting would encourage uptake before a harvestable crop is available. This means the annual income per hectare could be between £45,000–£150,000 with a relatively low outgoing, once established. Sphagnum moss is slow to establish and this can be a significant risk, especially in drought years. Horticultural fleece has been shown to help with this.

Practical management considerations

Sphagnum farming should aim to achieve sufficient rain-fed water supply without lakes forming. It should also reduce the stress imposed by previous agricultural nitrogen loads and alkalinity from lime use.

In trials, sphagnum lawn development was highest where:

- The top layer was removed. This takes away unwanted nutrients and can be used to level up access paths or bunds. It looks likely that if you do not take away the top layer the methane emissions will offset the carbon dioxide and nitrous oxide savings.[52]
- The water table is 2–10cm below the surface (please seek advice on drain blocking) as this may impact neighbouring farms.
- Drip irrigation was used, as opposed to sprinkler irrigation.[53]
- The incoming water was weakly acidified by the surrounding sphagnum biomass.
- Drought conditions were avoided using solar pumps and remote sensors.
- New sphagnum plants were spread either in the form of fragments, plugs or beads with *Sphagnum palustre* performing best.
- A covering of straw was used which did not exceed 3 cm thickness to allow sufficient light to reach the sphagnum.[54]

Sphagnum lawns suffer from:

- Hot and dry summers, such as in 2018.
- Irrigation mains water (alkaline water can kill sphagnum within days).
- Too much nitrogen, although surrounding vascular plants can mop this up (e.g. cotton grass, moor grass or an initial paludicrops like typha).[55]
- Overcrowding from vascular plants that outcompete for sunlight. It may be important to mow them monthly (without removing biomass) to let the sphagnum dominate.
- Harvesting with unsuitable machinery.

6.3: Management option – Typha and Phragmites (reed) farming

Reeds can be established on both peatlands and mineral soils and are commonly used for wastewater treatment in constructed wetlands.

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	No
CO2 emissions offset	Yes
Nature recovery	Yes
Water catchment	Yes
Eco-tourism	Potentially for bird watchers
Credit schemes	Carbon sink, CO2e offset
Livelihood without subsidy	Yes

Income opportunity, costs and risks

Typha has insulation properties, and common reeds are used in thatching because its high silica content is resistant to mold. There have been UK trials to create biomass for wood burning stoves. The pelletising and briquetting process is described in the textbook Paludiculture – productive use of wetlands. Establishing stable market for products appears to be the stumbling block. The economics have only been explored within a northern European context but are likely to be directly applicable to the UK.

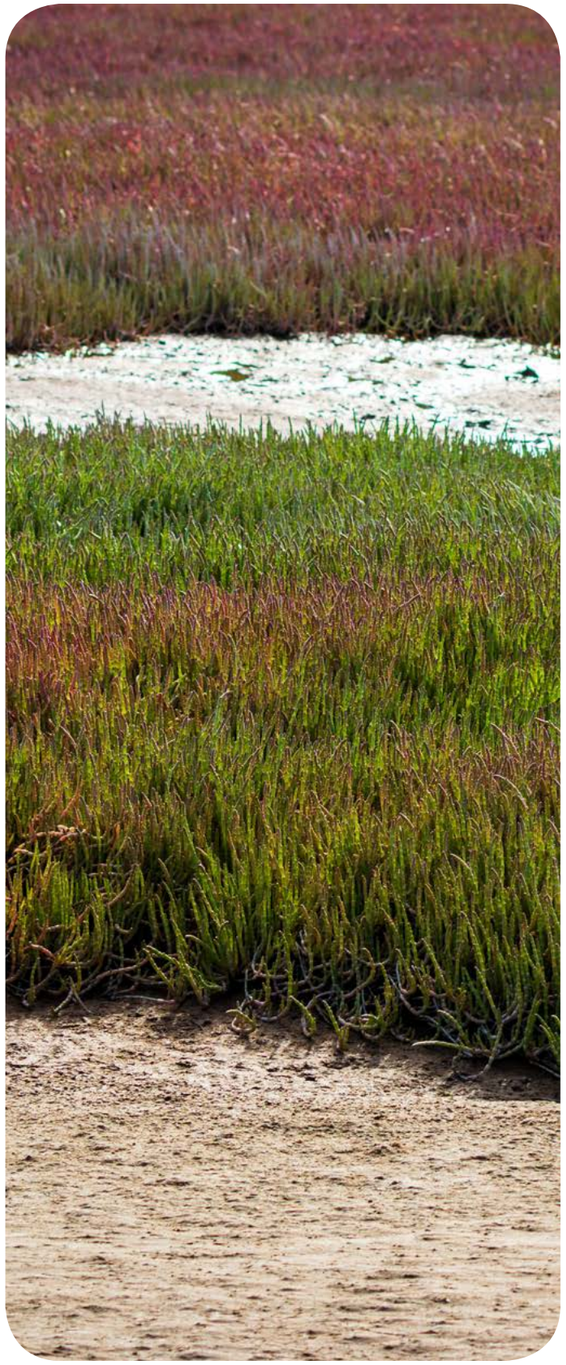


Table 6: Comparison of markets for reed dominated vegetation per hectare in €2016 prices[56]

	Summer for biogas	Winter for combustion	Bundles for thatch
Revenues from sale	100	416	1000
Variable machinery costs	196	156	112
Labour costs	65	70	280
Fixed machinery costs	162	199	125
Profit margin	-323	-10	483

Excluding initial establishment costs

This means the annual income is between £100 and £1000 per hectare with costs including labour of around £500 per hectare. This makes the economics marginal, unless the farmer is also involved in processing the product or thatching.

Practical management considerations

Reed farming requires a raised water table, this activity is discussed in 5.2, 5.3 and 6.2. Establishment is best when the turf is cultivated to create a seedbed.

When planting reeds, recommended planting densities are:

- Typha 5000–10000 plants per ha (1 plant per m2).
- Phragmites 20,000–40,000 rhizomes per ha (4 plants per m2).

Seed sowing is the cheapest method. Whilst the yields will be low in year 1 there will be catch up from year 2.[57] Seed sowing requires accuracy of the water table to between 0–5cm in the first few weeks. Once the plants are established it will be necessary to provide prolonged surface flooding of 5–30 cm depending on the young plants' height.

Paludicrops suffer from drought damage if the water level is <10 cm below the soil surface. Phragmites has a stronger tolerance of variable conditions. If pH is below 4 and the water table is too low then juncus / sedges will dominate. Paludicrops can be harvested in different seasons, depending on their intended use among a wide range of biomass applications. It is a trade-off between moisture content, yield, and optimal, sustainable nutrient removal from surface water and soil. Sustainable yields of 10–25 tons of dry matter per hectare are possible. Typha biomass can even be harvested twice a year under ideal conditions.

Pioneering story from Western Pomerania, Germany - *Aldert van Weeren*

We rent a listed farm in a mountainous area close to the Belgium Border. We also organise small nature-travel trips. I originate from a Friesian Island and my wife from the Baltic Coast. Emotions drove us to the sea (I am a landscaper and master mariner by trade). We bought a house at the Stettiner Haff, an inlet at the Baltic Coast. The house is positioned on a dead end road 8 km long, running through a rewetted peatland nature reserve. For decades it was drained as pasture land. Then, in a winter storm in the 1990s, the dyke broke, never to be rebuilt. The water came back. Sometimes it stands just above the soil line, sometimes just below it. For agriculture, it seemed, large parts of the land were lost.

I wanted to insulate my house in a completely natural way. Research pointed me towards cattail (typha) but I could find no farmers, so in short I decided to grow it myself. Working alongside the Hampf-fibre factory, Uecermark in Prenzlau, the project was a success. My house has become a place often visited by peatland researchers from all over Europe and I have teamed up with the Greifswald Mire Centre.

Aside from the ecosystem services, the potential for cattail includes:

1. Cavity wall insulation

2. Tendril waste for packaging

3. Pure plant fibres to replace plastics e.g. we are looking at car interiors and furniture

4. Silage for fodder or anaerobic digestion

5. Pollen as fodder for predatory mites in glasshouses

I am keen for cattail to be registered as an agricultural crop that can attract subsidies. I was recently invited to see the UK Broads at Petersborough for myself. They are marginal lands and I suspect the draining of them will eventually stop because of flash flooding and dry summers. We clearly need an alternative as wet land, prone to flooding, makes it almost impossible to get an economical grass fodder crop. My advice to farmers would be to start thinking about the paludiculture alternatives before you are forced into it. Is it really viable to keep adapting grassland species that bring diminishing returns? Farmers do have choices.

The economic viability of cattail marketing will rely on teaming up with manufacturers and getting the harvesting machinery to work. There are many good machines for phragmites reed cutting, but brushing and binding do not work especially well for cattail. There are some retrofitted "snowcats," with special wetland tracks who have very low soil pressure but there is no one perfect machine yet. There are possibilities of building a machine to order, but prices can be up to £300k and are too high for this emerging agriculture. Machinery pooling and working in cooperation is the key. We do not like caterpillar tracks as they cause too much damage.

Currently, we make do with one from BCS which was originally for linen crops (see photo). It has a slow pace for the cattail. With the Wetland Product Foundation, we bought two older 2.5 ton Seiga harvesters with balloon tyres, which makes the machine swim when it becomes too wet. In partnership with our Polish reed cutting partners in the region, we look forward to optimising the cutter/binding system on those. My dream harvester would be a Loglogic Softtrac with a hydraulically driven trailer and a bespoke BCS binder head fitted to work with cattail.

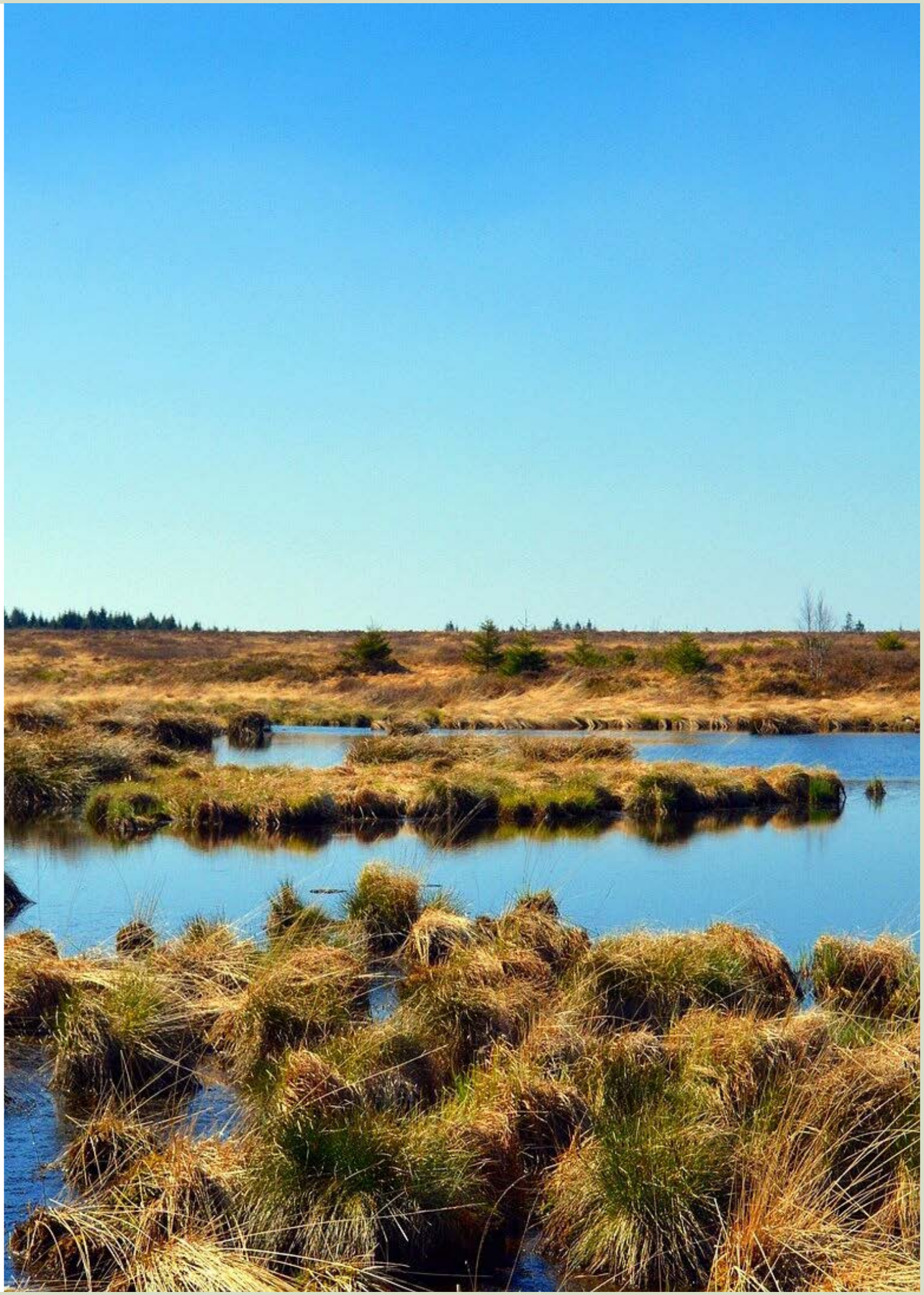
Paludiculture has improved my life. I love the interaction between science and farming to create a nature-inclusive kind of peatland use. I am in a position to show it can work, although there is a way to go for the paradigm-shift we need. We need "public goods" to pay the farmer for better biodiversity, less CO2 emissions and better water quality. Let's see what happens with the new regulations in the UK.

6.4: Resources

The management options discussed will work best when there is a fencing "exclosure" of the outer boundary to keep out grazing herbivores (e.g. deer, rabbits and squirrels) who can damage paludicrops.
The British Deer Society offer advice around fencing
The British Deer Society - Deterring Deer

On vast tracts of land reintroductions of apex predators, like wolves or pine martens, could achieve the same and are aspired to by the rewilding movement.
https://www.iucn-uk-peatlandprogramme.org

The leaders in Europe are the German Greifswald Mire Center (GMC) have produced the textbook with English translation
Paludiculture – productive use of wetlands.[58]



Chapter 7
Woodland, coppice & hedges

7.1: Why we need to plant trees and hedges – carbon sinks, nature, timber imports, land values

Sensitive management and supporting new woodland planting can benefit nature as well as acting as a carbon sink. When people imagine carbon offsetting, woodland planting is the approach that generally comes to mind. Most of the uplands below 600 metres would have historically been covered by broadleaved woodland. However, in many upland areas woodlands are now confined to steep-sided valleys, providing they are not grazed.

Woodlands are fantastic spaces for recreation and are very much loved by the public, but they need a long-term purpose to survive multiple generations. Author Nelson Henderson said, "The true meaning of life is to plant trees, under whose shade you do not expect to sit." This implies that there is a depth of meaning that we can bring to our lives when we take action for something greater than ourselves, and woodland planting has come to exemplify this.

Natural woodlands in the UK cannot provide all the wood we demand as a society. Demand for timber and wood products in the UK greatly exceeds domestic supply; the UK imported approximately 25.8 million tonnes of wood products in 2019.[59] Extensive planting of conifers may provide a better economic return but are generally of little value for biodiversity. Farmers may need to overcome their fear of forestry especially around land values.[60]

Carbon credits

The carbon market in the UK currently exists as a voluntary market. The Forestry Commission and other stakeholders have developed a Woodland Carbon Code to establish a common set of standards for investment. All woodland projects must conform with the UK Forestry Standard[61] Investors buy verified carbon credits through the Markit Environmental Registry[62] and this market is expected to expand based on UK companies' need to report their greenhouse gas emissions. To accelerate uptake of the scheme from 2020, DEFRA guarantee to buy a certain amount of Woodland Carbon Units (WCU).[63]

The guaranteed price for CO2 is agreed with the government through an online reverse auction in £/tCO2. If the auction bid is successful, the government will offer a conditional 30–35 year contract to buy the carbon dioxide, with the price agreed at auction being index-linked to protect against inflation.

7.2: Management option – Broadleaved trees for timber

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	Potentially fuel wood from brash removal
CO2 emissions offset	Yes
Nature recovery	Yes
Water catchment	Yes
Eco-tourism	Yes
Credit schemes	Carbon sink, CO2e offset, flood alleviation
Livelihood without subsidy	No

Income opportunity, costs and risks

Planting timber trees is an investment beyond the lifetime of one person. Start-up costs per hectare vary between £4000–£8000[64] and involve saplings, either deer fencing exclosure (see resources 7.11) or tree guards and stakes. Other maintenance equipment includes brush cutters, mowers and chainsaws. The lifetime costs are between £3200–£7870.[65] The income potential is linked to ELM and carbon offset. The long-term risks to planting woodland are fire, flooding and tree diseases.

Practical management considerations

From the author's own experience, growing young trees in a ley of long-term green manures like clover will assist the growth. On more marginal land where clover will not take, Italian alder planted to the north of the timber trees and eleagnus, gorse and broom planted within the stand may assist with nitrogen transfer. The only timber tree that is likely to be successful on very waterlogged soils is alder (itself a nitrogen fixer). In terms of coppice trees, willow can be successful on waterlogged soils. The use of ramial chipped wood on bare soil can cause problems with nitrogen lock up and must always be applied to either green manure or grass. This is discussed in 8.2.

In general, just six species are the main producers of quality timber: ash, beech, cherry, oak, sycamore and sweet chestnut. The effects of exposure on stem form usually limit the growing of quality hardwoods to areas below 300m above sea level. Soil pH is one of the most important site factors to consider. Choice of species is restricted on thin alkaline soils to sycamore (Italian alder and Norway maple are also well suited), but on deeper alkaline soils the choice widens to include ash, cherry and beech. Oak should be established on deep, fertile, acidic clays and loams because these sites are optimum for the species and are believed to reduce the incidence of shake. Acidic, predominantly sandy, soils are generally unsuitable for growing quality hardwoods, except sweet chestnut in the south of Britain.
High pruning will be needed with most trees to ensure a straight and knot-free bole of 6m (20ft). This raises the tree canopy and allows more light to reach the ground. It should be noted that closed-climax forestry reduces opportunities for biodiversity.

Table 7: Stocking densities for timber trees

	Stocking per hectare	Spacing Initial in square metres	Spacing Final in square metres	Final Crop trees	Rotation Years
Beech	3100	1.8	6.3	250	95–140
Oak	3100	1.8	7.1	200	120–160
Ash	2500	2	5.3	350	65–75
Sweet Chestnut	2500	2	6.3	250	60–70
Sycamore	2500	2	5.3	350	60–70
Cherry	1100	3	6.3	250	60–70

7.3: Management option – Fast growing nursery timber trees

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	Potentially for fuel wood
CO2 emissions offset	Yes
Nature recovery	Yes
Water catchment	Yes
Eco-tourism	Yes
Credit schemes	Carbon credits, CO2e offset, flood alleviation
Livelihood without subsidy	Potentially if planted in succession

Income opportunity, costs and risks

Faster growing timber trees to be brought on as nurse trees offer another land management option. Some nursery trees may be economically viable e.g. as Christmas trees but would need to be harvested before they became too big and planted in succession to have annual income.

Practical management considerations

Many of the considerations are the same as in section 7.2. The nurse trees are later thinned and removed. According to Martin Crawford[66] (Agroforestry Research Trust), that should happen when the crop tree has a bole of the required length (between 3–6m).

Table 8: Fast growing nursery trees

Crop Species	Nursery Species
Ash, Oak	Sycamore, Black alder, Red alder, Sweet chestnut, European larch, Norway spruce, Corsican pine, Scots pine.
Sycamore, Beech, Sweet chestnut	Italian alder, Lawson's cypress, Larches, Norway spruce, Lodgepole pine, Radiata pine, Scots pine, Cherry, Coast redwood, Western red cedar.
Cherry	Italian alder, Larches, Hybrid poplars, Douglas fir, Lodgepole pine, Radiata pine, Coast redwood, Western red cedar.

7.4: Management option – Woodland by natural succession

Woodland by natural succession[67] is also a form of "self-willed" rewilding. The conservation of local genetic stock of trees and wild plants is important, and this is why this technique is favoured by some ecologists over planting saplings bought from a tree nursery.

Putting up exclosures around ravines across the UK would greatly help to improve the water holding capacity of soils within a relatively short space of time.

Moors for the Future Partnership (MFFP)[68] provide detailed resources for for clough woodland (woodland that is found in ravines and steep sided land by moorland), especially around flooding alleviation. Any new woodland should be created in accordance with the National Vegetation Classification (NVC) to the site.

This includes:

W17 – Upland Oak-Birch with Bilberry

W11 – Upland Oak-Birch with Bluebell

W4 – Birch Woodland with Purple Moor-grass

W7 – Alder-Ash woodland with Yellow Pimpernel

MFFP state that natural colonisation is generally the preferred method of woodland establishment which will require herbivore exclusion with deer-proof fencing under agreements. This creates a natural look and conserves local genetic distinctiveness and diversity. If supplementary seeding is required, it should be sourced from local woodlands. A decision on whether to retain "exclosures" in the longer-term will need to be made on a case by case basis.

It is possible to plant trees with guards and avoid using exclosures, but herbivores will take out the understory which is part of the nature recovery.

Above: Land allowed to naturally regenerate with hazel saplings in the foreground, red campion mid and standing dead wood and larger hazels in the back.

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	Potentially fuel wood from coppice and brash removal
CO2 emissions offset	Yes
Nature recovery	Yes
Water catchment	Yes
Eco-tourism	Yes
Credit schemes	No
Livelihood without subsidy	Carbon sink, CO2e offset, flood alleviation

Income opportunity, costs and risks

Grazing wild herbivores such as deer, hare and rabbit can be kept at bay with a fencing exclosure. However, woodland by natural succession may actually cost nothing if just left alone. This type of land management should attract ELM payments or carbon offset but is harder to quantify than planting trees. Risks occur when there is insufficient local genetic stock to support natural succession, when the site becomes swamped with invasive species such as brambles, or if the fencing is breached and grazers, which can include geese, decimate all the young plants. Climax closed-canopy woodland has less value than a mosaic of habitats so it could well be that a woodland, by natural succession, may still be managed by coppicing (see 7.5).

Practical management considerations

Tips for encouraging natural succession include:

- Deer and rabbit exclosure fencing.
- Using tines on the forest floor/field to enable germination, as compacted, eroded or waterlogged soils inhibit germination.
- Giving species that struggle to disperse themselves naturally, such as aspen, a helping hand.
- Monitoring bramble levels as they can shade out young seedlings or prevent straight growth. However, at the same time they can protect seedlings against browsing animals and frost.
- Removing non-native and invasive species especially rhododendron, giant hogweed, Himalayan balsam and Japanese knotweed.

Once saplings are established:

- Tree shelters can be placed over the young trees by early September of their first year, the aim being to protect at least 1100 trees per hectare.
- Dense regeneration allows greater selection of crop trees by thinning. Frequent "light" respacing is preferable to one heavy thinning. Reducing stocking to 10,000 trees per hectare on the first occasion and to more normal levels two years later (2500–3500 trees per hectare).
- Restock any gap larger than about 7m x 7m in the Autumn of year 1.

To assist with the return of beneficial wildlife, ecological niches like deadwood can further support this habitat.

7.5: Why we need coppice – expansion of sawmills, wood chip, pulp

Planting a broadleaved woodland is a long-term project which takes many decades and is often beyond one person's lifetime. Coppice may offer more opportunities for farmers. Oliver Rackham in his influential work *Trees and Woodland in the British Landscape* estimated that about half of England had ceased to be wildwood by 500BCE. Much of the remaining woods were managed for coppicing. Neolithic humans had discovered that the regrowth from a stump is more useful than the original tree.

The Committee for Climate Change have called for an expansion of the forestry sector. There are established markets for a range of timber species. Sawmills and other processors can cater for coppice products that will grow within much shorter timeframes, such as:

- Small-diameter softwood material from conifers for fencing material or pulp/chipwood production, to larger-diameter sawlog material for construction.
- Timber and woodchip to be locked up in buildings. This is one of our best forms of carbon-capture, and includes woodcrete breeze blocks, cross laminated timber and orientated strand board.
- High-grade hardwood logs for planking or veneer and poplar for packaging and carcassing.
- Sweet chestnut fencing paling or hazel hurdles.
- Younger sappy wood for ramial wood chip (discussed in 8.2), biochar and biomass energy.

7.6 : Management option – Sweet chestnut and hazel coppice

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	Potentially for fuel wood
CO2 emissions offset	Yes
Nature recovery	Yes
Water catchment	Yes
Eco-tourism	Yes
Credit schemes	Carbon credits, CO2e offset, flood alleviation
Livelihood without subsidy	Potentially once established

Coppice is a sustainable system of woodland use, with some coppices still being worked after 800 years with no significant decline in growth. Phosphorus levels may gradually decline in time, but there is little evidence of growth decline and no fertilisation is needed.

Income opportunity, costs and risks

The income opportunity is linked to turning the coppice timber into a useful product. The start-up costs are £2220–£3420 (based on willow) per hectare[69] and the annual costs per hectare are likely to be similar to woodlands. The risk factors are common to all woodlands (see 7.2 and 7.4). Sweet chestnuts are much more sensitive than hazel with the latter being able to be planted in most places. Like all perennial crops, there is a lead-in time until harvest.

Practical management considerations

Sweet chestnut coppice is native to southern Europe but was introduced in Roman times. It is suited to warmer, more continental parts of Britain (i.e. <1500 mm rainfall per year) on medium to poor soils of fresh or slightly dry moisture status. It is not suited to alkaline or waterlogged soils. Acid sandy loams are an ideal soil type for this species which, although cold hardy, is not tolerant to exposure. Chestnut is susceptible to several root borne pathogens, as well as chestnut blight, and that is why it is suited to non-compacted and well drained sandy soils. If you can get them to grow, then the next major problem is squirrels ring barking the trees from about year 8 onwards. The solution may be squirrel netting, fencing or the reintroduction of pine martens.

Rotation years	Stools per hectare	Spacing metre
7	1500–2000	2.2 – 2.6
10	1200–1500	2.6 – 2.9
15	800–1000	3.2 – 3.5

Chestnut coppice – Say it with Wood

Toby Allen is from www.sayitwithwood.co.uk, a company that specialises in chestnut coppice products. The main market is for cleft chestnut for fencing grown on a 12–6 year rotation. They manage coppice for other landowners and have a mobile sawmill. The coppiced sweet chestnuts are not used for nut production.

Toby says, *"If a farmer was to come to me for advice I would suggest firstly thinking about what they could use within their farm, and then in the wider community. This is because a local supply chain is far stronger than selling into a big market. For example, we use chestnut coppice to make fencing materials. The other consideration is willow for local basket makers or growing mixed coppice to make ramial woodchip (discussed in chapter 7) and biochar to sequester carbon in the soil.*

"During the establishment phase of sweet chestnut it is important to keep the weeds down, which we do with a brushcutter, and keep the deer off. Understoreys of plants like bluebells come on their own. However, they can actually create very slippery conditions with harvesting. We take the first cut at 3–5 years and this is sappy and better for ramial chipped wood or biochar. Then we take another cut after 10 years or so for the fencing.

"From our personal business perspective, harvesting chestnut is expensive (£25–£40/ton). This money is not paid back until we have turned it into a product and sold it. From a landowner's perspective, the money is pretty straightforward, as they get paid from the weight that goes out the gate. Standing prices vary on access and quality. Once the coppice is working it is fairly easy money. I predict coppice and woodchip will only go up in value.

"Growing trees pull carbon dioxide out of the air and turn that into carbohydrates to grow a trunk. At the same time mycorrhiza fungi connected to the tree's roots pull carbon into the ground in exchange for nutrients. Making products from trees stores that carbon. Sweet chestnut fencing grown locally is as good as it gets.

"My recommendation for any farmer is to use both ramial woodchip and biochar to increase carbon in the soil, which in turn makes the land more productive and healthier with less need for chemical inputs. There is also a domestic gardener's market for these products. It would be good to see a woodchip industry linked to CHP ((combined heat and power) district gasification plants as a renewable heat initiative. The upside of biomass energy is that the quality does not really matter. Pulp is also a useful product. Turning land over to growing trees for other people to plant out would definitely fill a need in society. There is likely to be a significant demand for young trees in the near future so a bareroot or plug trees nursery would be a good option for change of use.

"At the end of the day we need to cultivate a stronger wood culture between farmers. A coppice crop to supply a local need is a strong supply chain. We are members of the Confederation of Forest Industries and their work is really valuable to us."

Photo credits: Say it with Wood.

Hazel Coppice

Hazel is a shrub which usually grows to 5m high (but sometimes twice that height and tree-like in form) and 5m spread. Coppice stools can live for several hundred years, have a tap root, and are relatively shallow rooted. Hazel tolerates a wide variety of soils, from calcareous to acid loams and clays. It is usually found in hedges and in lowland or upland deciduous woods as part of the understorey, being found in Britain up to an altitude of 600m. It is frequently found with alder, ash, birch and oak. Hazel has the opposite requirements to sweet chestnut as it is relatively shade tolerant and likes cool, moist summers and mild to cool winters. It does particularly well in areas with oceanic-influenced climates. Areas with high summer temperatures are not very suitable. The foliage is very attractive to grazing herbivores.

A 7–10 year rotation is the norm with a density of 1500–2000 plants per ha with 2.2–2.6m between plants. The poles from coppice are long and flexible and have been traditionally used for many years for wattle fencing, where branches are usually split, then weaved to make sections of fence. They are cut when they are approximately 5m long and cutting normally happens in the winter months. On good sites with a stocking rate of 1500 stools/Ha, a yield of about 20 tonnes of dry wood per Ha is possible with each rotation leg.

A common practice with hazel is "coppice with standards". This is a two-storey forest, where among the hazel coppice (underwood) are grown some trees (standards) for large timber, normally oak trees. Between 30–100 oak trees per Ha (12–40 per Acre) are grown with the coppice. Oak standards are generally retained for 100–130 years before felling. Side branches are pruned off oak standards to ensure high quality timber.

Neglected hazel coppice (unlike most other coppice, which can be restored), only remains viable for 40 years or so before neglected stools start to die. Growing for hazel nuts requires the trees to be more in direct sun and may suit alley cropping. Cobnut varieties do not tend to do well on marginal sites.

7.7: Management option – Biomass for renewable energy, pulp and chip (willow and miscanthus)

It could well be that perennial bioenergy crops are part of the story of transition towards a more sustainable energy system. Short Rotation Coppice (willow) and miscanthus (elephant grass) can be planted on contaminated land. Currently production of perennial energy crops is very limited in the UK (~10,000 ha) with little change in the last 10 years.
Not all biomass renewables are carbon-neutral if they displace arable land, require forests to be cut down, use too many fossil fuels during their lifecycle or if they take a long time to grow back. Wind and tidal power have more potential to produce renewable energy over biomass and so all techniques are complementary within "power-down" scenarios.

Table 9: The sustainability debate with UK grown biofuels[70]

Sustainability Indicator	Good practice for climate and nature recovery	Bad Practice
Biodiversity	Short rotation coppice can have positive benefits for pollinators Thinning forests can improve biodiversity e.g. more sunlight	Planting monocultures Replacing existing forests with SRC Displacing arable crops Heavy machinery and rutting Planting in sensitive locations
Soil health	Leaving residues Willow makes efficient use of nitrogen Woody perennials have lower fertility requirements and do not require tillage	First generation annual biofuel crops e.g. maize are associated with soil damage and high fossil-fuel inputs Bioenergy may prevent organic wastes returning to land
Water quality	Woody perennials tend to have low nitrogen loss	First generation annual biofuel crops e.g. maize can lead to sediment and eutrophication of waterways
Heavy metals and air quality	Woody perennials can sequester heavy metals	Particulate matter when biomass is burnt, particularly for small-scale and domestic bioenergy for heat uses where no filters are fitted
Resilience and safety	Integrated food and bioenergy crop systems help diversify	Steep slopes can make unsafe work environments.
Transport	Decentralisation with Combined Heat & Power (CHP) plants to reduce transportation	Subsidies should no longer go to large biomass plants

The CCC notes that combustion of biomass crops may be required initially to replace some fossil fuels. However, the 2050 direction of improvement is that biomass will not be combusted but manufactured into construction materials e.g. timber in buildings, woodcrete and bioplastics, which in themselves will be a carbon sink. This has the potential to contribute to the circular zero waste economy agenda.

Short rotation willow coppice

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	Yes
CO2 emissions offset	Yes
Nature recovery	Yes
Water catchment	Yes
Eco-tourism	No
Credit schemes	Carbon credits, CO2e offset, flood alleviation
Livelihood without subsidy	Potentially once established

Income opportunity, costs and risks

The startup costs include fencing exclosure, nursery cuttings, tree guards (if no exclosure), mulch, brush cutter or mower. All costings are offered by Vivid Economics.[71] Start-up costs are likely to be in the region of £2220 to £3420 per hectare with ongoing annual costs between £380 to £665. The annual income from the processing plant per hectare is likely to be £1050 but as willow is harvested every three years it would be £3150 at the point of harvest. Willow is very robust and relatively easy to grow while miscanthus is more sensitive.

Practical management considerations

Planting is always related to proximity to a processing plant. Examples of such plants include:

- Workington Cumbria for short rotation coppice Willow for biomass energy and paperboard[72]
- Lincoln Mill for Miscanthus home fire and horse bedding products.[73] They offer a farmer calculator service.

These companies provide long-term contracts, advice and support to farmers. According to a stakeholder day,[74] high establishment costs and delayed revenues from harvestable biomass are perceived barriers. The specialist equipment for harvesting is not readily available and there is a lack of trust in agronomic advice with examples of poor establishment. There is also a lack of trust in end markets with farmers needing strong reassurance that new markets will not fail. To deliver an increase in scale will likely require further guarantees from the government.

The CCC argue that the planting of energy crops should be prioritised on low grade agricultural land (grade 3b, 4 and 5) where conditions are suitable to establish an economically productive crop and where machinery can access the site.

Table 10: Broad cost-benefit analysis of Short Rotation Coppice and miscanthus 2020 prices[75]

	Planting & establishment costs *per ha*	**Maintenance costs** *per ha per year*	**Production costs including carting** *per ha per year*	**Yield dry matter** *per tonne per ha per year*	**Annual Income** *per ha once established*
Short Rotation Coppice Willow	£2220	£50	£990 + 3 = £330	45 ÷ 3 = 15	£3150 ÷ 3 = £1050
Miscanthus	£3420	£50	£615	15	£1050

**Please note SRC is harvested every three years and the figures have been adjusted for comparison reasons.*

Short Rotation Coppice willow is established from cuttings prepared from one-year-old wood produced by specialist nurseries. The cuttings are inserted into the ground in spring with the density of 15,000 per hectare. At the end of the first growing season they are coppiced to ground level to encourage the development of the multi-stemmed stools. Growth is rapid after cutback and can be as much as four metres in the first year, increasing to 6–8 metres at harvest in three years (short rotation) following cutback. A willow coppice may be harvested six to eight times on a three-year cycle giving the plantation a life of 19–25 years allowing from the first or establishment year.
Miscanthus prefers improved sites and will do better in the south and east of England. Its returns are not as good as that of Short Rotation Coppice because of annual harvesting (compared to every three years), however, it is a better crop for cash flow.

7.8: Management option – Hedges as carbon sinks and for hedgehogs and foraging

Since the Second World War, hedgerows have been removed at a much faster rate than they have been planted. In some parts of the country 50% of hedgerows have gone,[76] while others are so badly managed that their value to wildlife is much reduced. While hedgerow planting is not a land use option in its own right, it can bring many benefits as a carbon sink and wildlife corridor for nature recovery. Likely hedge species include hawthorn and blackthorn, and foraging hedge species include crab apple, bullace, damson, pear, blackthorn (sloe), brambles, cherry plums, rosehips, rowan and hazel.

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	Potentially with fuel wood
CO2 emissions offset	Yes
Nature recovery	Yes
Water catchment	Potentially
Eco-tourism	Potentially foraging
Credit schemes	Carbon sink, CO2e offset, flood alleviation
Livelihood without subsidy	No

Income opportunity, costs and risks

The startup costs include the nursery plants, tree guards, stakes and are likely to be in the range of £360 to £3200[77] per 100m. The lifetime maintenance costs are low at £130[78] but this excludes hedge laying. The establishment of hedges can be overwhelmed by weeds or grazing and so can be assisted by a fencing exclosure.

Practical management considerations

Planted trees and hedges can allow wildlife to pass through and have a home. The decline of rural hedgehogs could be reversed within a decade by mandating the replanting of native hedges around agricultural fields and then creating a system of rotational laying. Hedgehogs cannot tolerate gap-ridden, flail-mown hedges.

Photo credits: Lancashire Wildlife Trust..

Predicting the carbon sequestration potential of hedgerows[79] is difficult especially when many are kept short or with gaps. Reviving the traditional skill of hedge laying could help to improve quality and management of hedgerows. Once a hedge has been laid, regular trimming will keep it in good order for up to 50 years when it may be appropriate to lay the hedge again. A standard metric and carbon credit scheme is needed to reward farmers for keeping hedges and which could incentivise them as carbon sinks.

7.9: Resources

The management options will work best when there is a fencing "exclosure" of the outer boundary to keep out grazing herbivores (e.g. deer, rabbit and hare), who can damage young saplings and plants.

The British Deer Society offer advice around fencing
The British Deer Society: Deterring Deer

On vast tracts of land reintroductions of apex predators are aspired to by the rewilding movement.

https://www.forestresearch.gov.uk/documents/1699/FCHB009.pdf

In the Highlands of Scotland there has been a 25-year initiative to bring back the Caledonian Forest.
www.treesforlife.org.uk

https://www.forestresearch.gov.uk/research/woodland-for-water-woodland-measures-for-meeting-water-framework-directive-objectives/

https://www.woodlandtrust.org.uk/media/1761/keeping-rivers-cool.pdf

https://www.agroforestry.co.uk/about-agroforestry/timber-tree-species

Martin Crawford (1995) Chestnuts Production and Culture. Agroforestry Research Trust

Martin Crawford (1995) Hazel nut Production and Culture. Agroforestry Research Trust

An ETI Perspective - Bioenergy crops in the UK

Short Rotation Coppice Willow - Best Practise Guidelines

Chapter 8
Food crops on marginal land

8:1 Addressing imports, obesity, food waste and the decline of soil carbon

Our current land use does not match the requirements of healthy diets for the UK population. For example, three quarters of all fruit and vegetables eaten are imported.[80] There are overconsumption and inefficiency issues such as feeding grain to farmed animals and excess demand for seed vegetable oils for use in processed foods. It is estimated that the NHS spent £6.1 billion on overweight and obesity-related ill-health from 2014–2015.[81] WRAP estimated annual food waste within UK households, hospitality and food service, food manufacture, retail and wholesale sectors in 2018 at around 9.5 million tonnes.[82]

Underpinning our wasteful food system is a system of agriculture which is exploiting soils. Intensive agriculture has caused arable soils to lose about 40–60% of their organic carbon content.[83] Almost 4 million hectares of soil are at risk of compaction in England and Wales, affecting soil fertility and increasing the risk of flooding.[84] This chapter examines ways to improve soil carbon in cultivated soils through the use of long-term green manures in rotation and wood chip. These strategies can enable marginal soils used for grazing to be converted into productive food growing systems.

A movement away from "tonnes per hectare" to the concept of "people nourished per hectare"[85] encourages a better use of land resources.

Suggested ratios[86] of arable land use for plant-based agriculture are:

- 60% grains including pulses
- 30% starch-based vegetables e.g. potatoes, beetroot, parsnips and squash
- 10% perishable vegetables e.g. leafy greens and salads, with the possibility of a large part of this category happening on allotments and peri-urban market gardens

The star performers for "people nourished per hectare" are starchy root vegetables like potatoes on cultivated land and forest gardening/orchards on grade 3 and above. In the south of England sweet chestnuts, cob nuts and walnuts have the potential to produce significant protein crops in the human diet. On some marginal land (with mineral soils) it will be possible to cultivate and also raise soil organic matter content. However, this guidance does not recommend the wholesale cultivation of marginal land as that would have severe impacts on climate and biodiversity. Conversely, this guidance does not recommend turning quality arable mineral soils to pasture, wood-pasture, forestry or bioenergy because that is incompatible with feeding rising populations.

Tillage is a significant cause of soil degradation in arable soils, but is tolerated as a necessary practice to remain productive under existing agricultural techniques. Both total cultivated area and the impact of tillage must be managed.

At a society-wide level, the arable land footprint can be significantly reduced by:

- Not feeding grains to farm animals.
- Not growing grains for bioenergy.
- Reducing food waste from the industrial food system.

At the farm level, the effects of tillage can be significantly reduced by the farmer:

- Adopting nitrogen fixing leys in rotation.
- Applying wood chip to these leys to raise soil organic matter levels.
- Overwintering green manures to ensure roots are in the soil and to prevent bare soil and nitrate losses.
- Recycling society's organic wastes.
- Ending the use of biocides which deplete soil microbiota/carbon life-forms.
- Growing and then laying hedgerows (which are essential hedgehog habitat), that also act as windbreaks.
- Alley cropping e.g. nut and fruit trees alongside arable crops.
- Creating wildlife margins in fields (e.g. wildflowers and beetle banks).

Biochar is favoured by some growers to improve carbon content of soils, but it has not shown itself to be the "silver bullet" many felt it would be. Research into this is commercially sensitive and products are subject to intellectual property rights presenting a challenge for new growers seeking information. Wood chips are far more straightforward providing you have a chipper and a small willow coppice.

8.2 Management option – Vegetable crops on grade 3b, green manures and woodchip

Public Goods	Does this contribute?
Carbon sink	Potentially
Fossil fuel replacement	No
CO2 emissions offset	Potentially
Nature recovery	Potentially on margins and alleys
Water catchment	Potentially
Eco-tourism	Yes
Credit schemes	Possibly carbon credits if there is an element of woody perennials.
Livelihood without subsidy	Yes

Income opportunity, costs and risks

It is always possible at an amateur level to have a "plot" if the shelter and drainage is tackled. However, doing it on a commercial scale is more challenging and agronomic advice should be sought before proceeding. The vegetable growing techniques Iain Tolhurst adopts for commercial success are detailed in the book Growing Green: Organic Techniques for a Sustainable Future. (First published 2006, Revisions 2009 and 2015).[87]

The start-up costs moving from grazing to cultivation may involve fencing exclosure, seeds, propagation facilities, cultivation equipment, planting equipment, inter-row weeders and harvesting machinery. Excluding herbivores and pigeons is likely to be a significant cost and this can be done with fencing and giant (wildlife friendly) nets or mesh. It will be necessary to build soil fertility phases into the rotation. Box schemes also benefit from some form of protected cropping with a polytunnel.

Using the Soil Association HORT planning tool, assuming the grower is selling via a box scheme, a conservative estimate for annual income is £9347 per hectare. It is possible to turn over much higher returns by concentrating on salads, herbs and micro vegetables if linked to high-end restaurants. The annual costs per hectare are complicated by the fact there are no economies of scale. It can vary if you are selling from the field as a wholesale crop or selling direct to the customer through a farm shop or box scheme. Vegetable growing is demanding in terms of husbandry skills and customer liaison.

Practical management considerations

The two key techniques of soil fertility are green manures in rotation and woodchip. Nitrogen-fixing plants (with or without grasses), are the only means to replace Haber-Bosch nitrogen, if you are not to rely on "ghost acres" of fertility taken from another farm. The goal is to move toward closed systems of biologically created fertility where practicable.

Tolhurst Organic Produce

The leading example of a commercial operation on grade 3b land is Tolhurst Organic Growers, leading stockfree-organic vegetable and strawberry growers. Stockfree-organic means that all sources of fertility are from plants and agro-chemicals are not used. Over a 40-year period Iain 'Tolly' Tolhurst has managed to get yields comparable to using conventional methods. His fields have a rabbit fence "exclosures" with badger gates.

Tolhurst Organic field-scale rotation:

1. Green manure e.g. red clover, white clover, lucerne
2. Green manure (continued from year 1)
3. Potatoes
4. Brassicas – kale, cauliflower, sprouts, cabbage, purple sprouting broccoli
5. Alliums – onions and leeks
6. Umbellifers and beets – carrots, parsnips, beetroot (leafy beets are grown in the walled garden)
7. Squash and sweetcorn (undersown to long-term green manures in July which form legs 1 and 2 of the rotation)

As Tolly observes:
"It is not just the grade of the land; it is also the geography. We are in Reading and have a south facing field, so local climate is important. Marginal land in coastal warm pockets may do well, even in Scotland. The reality is the effort it takes to get the soil into good health may be the critical factor in deeming whether an operation can be commercially viable on what is deemed marginal land.

"If I could sum up in one word the secret of our success, it would be diversity'. Diversity of green manures, species of crops, wild species in the shelter belts, species in the soil flora – each of which bring resilience. The icing on the top of this is chipped branch wood which has boosted our earthworm populations to 12 million per hectare. Earthworms are a good indicator that everything is stacking up, and you have to remember we are taking a lot of crops off this land. Woodchip use over the past ten years has doubled our soil organic matter content.

"Ramial is sappy wood with a diameter not generally wider than 70mm across. We spread with a muck spreader at 70 cubic metre per hectare. This equates to 7mm across the land. We spread onto the long-term green manures in either winter or early spring depending on whether the soil conditions are good enough for the tractor and muck spreader.

"The green manures, which are rich in nitrogen, are capable of taking the high carbon of the woodchip and during the summer the woodchip is drawn into the soil by the soil fauna like earthworms. There is no nitrogen lock-up because it is not applied direct to bare soil. Hedgerows can also be trimmed for ramial chipped wood, but this is more work to put through the chipper. Ramial is not stock piled, where it could lose some of its energy through the composting process."

After long-term extractive practices, and if the soil is in very poor health, then it may be necessary to inoculate the soil with fungus. This can be done with fungal leafmould from the forest floor (at a depth of 5cm at a rate of 100kg per hectare) or buy a "Mycorrhiza mix". Woodchip is far less work than biochar, and similarly adds to the recalcitrant soil organic matter which takes a long time to degrade. Woodchip is not applied to bare soil, but to green manures in rotation. A detailed "how-to guide" for green manures is available from the seed merchant Cotswold Seeds called "Sort out your soil."[88]

Wood chip can be sourced from local shredded garden waste which can be composted in heaps on the farm or as ramial wood chip from purpose grown coppice that is shredded and spread on the same day. Fast growing willow is the easiest way to create ramial chips and their straight poles lend themselves to chipping. Fast growing poplars, alders or ash could also be used.

8.3 Management option – Orchards, commercial forest garden and alleys

Public Goods	Does this contribute?
Carbon sink	Yes
Fossil fuel replacement	No
CO2 emissions offset	Yes
Nature recovery	Potentially
Water catchment	Potentially
Eco-tourism	Yes
Credit schemes	Possibly carbon credits
Livelihood without subsidy	Yes once established

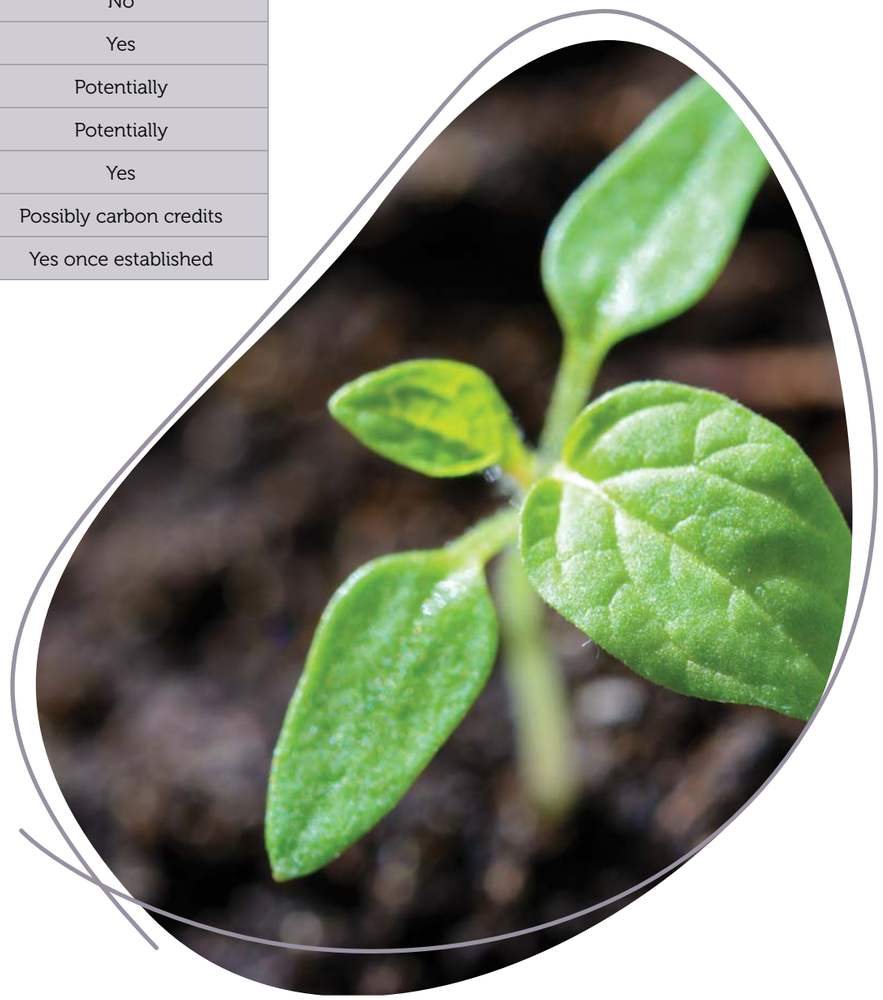
Income opportunity, costs and risks

Fruit growing can be highly satisfying, although it is important to seek professional advice about establishing it. Start-up costs include planting 100–150 trees per hectare.[89]

If the goal is to be a traditional orchard or more a forest garden with an understory, the establishment costs can be between £3000–£15,000. Plastic mulches can assist with establishment and grass is always the enemy of young trees. It is possible to get up to 22 tonnes per hectare once fully established for organic systems[90] with the income potential of up to £17,000. Annual costs are likely to be in the region of £9000[91] reflecting the cost of seasonal picking. There are many risk factors with orchards and they are sensitive to flooding, frost on blossoms, not enough nitrogen and various pests.

Practical management considerations

These are discussed in the Fir Tree Community Growers case study. The textbook by Stella Cubison *Organic Fruit Production and Viticulture (2009)* is an important starting point.



Fir Tree Community Growers CIC
– Orchards and commercial forest garden on marginal land in North West England

The forest garden = multi-layered orchard
Three year old forest garden storeys in order: Nitrogen fixing Italian alder to the north, then Katy apple tree, blackcurrants and the lowest storey of squash.

From the current author's experience, *"We are in the rain shadow of the Pennines, in St Helens, near Liverpool on marginal land on 2 hectares. It had its sand removed in the 1930s for sand extraction. When we took it on it had huge drainage problems. Our work over 17 years has been about getting water off the site. We added a large pond with an overflow pipe to a local brook, a large farm ditch and a meandering ditch to add to the beauty of the site.*

"Main trees are also planted on mounds to help with the drainage. As they are not planted in lines, this has posed a problem for mechanical mowing, so at present we hand scythe and rake in autumn/winter. We selectively scythe to reduce the levels of docks, ragwort and creeping thistle seed heads and all our work is to the stockfree-organic standards. I often wondered if we could have saved ourselves a lot of hassle planting in straight lines, but in time the randomness with mown paths will make the site much more a place of beauty and will, one day, feel like the Garden of Eden.

"We were very influenced by the work of Martin Crawford, of the Agroforestry Research Trust, around forest gardening and especially wider spacing than a commercial orchard. The goal is to avoid closed canopy. However, in time, we found that some of the more unusual crops did not work for us. These were figs, chokeberries, plum yew, saskatoon, pea shrub and eleagnus multiflora. The site is sadly too damp. What has definitely worked has been using nitrogen fixing Italian alders at the north of groups of main trees (dessert apple, pear and plum trees), as well as shelter belts of eleagnus ebbengei and eleagnus umbellata. The edible "glitter berries" are sought after by restaurants.

"We are great at growing blackcurrants and rose hips but we have struggled to really find the market because people tend to buy the former as frozen fruit, and no one really knows what to do with rose hips. So we intend in time for that to be "an experience" because we certainly don't have the time to pick blackcurrants commercially and are therefore moving away from berries. As we are a bit of a Noah's ark, having every named variety of black currant which does not have breeders rights, I suspect the real income from these is taking cuttings and selling the young plants. This hasn't happened to date because of my capacity, which I hope will ease once my children are older.

"Perennials and trees are staked (where appropriate) and have a re-useable plastic woven mat around them for the first five years to stop the competition from the grass roots. Nitrogen-rich dock leaves and compost are put under the mat. That is then removed, and grass is raked around the bases of trees as a feed. They are also initially inoculated with the fungal mix available from the Agroforestry Research Trust. The trees that have done best were also in a sward of red clover, but this has died out over time to be replaced by grass. We have had plastic spiral guards ring bark trees in the heat of the summer of 2018, and also had stakes which weren't strong enough.

It is important to get fresh air to the bark whilst keeping the rabbits, hares and voles away and we now use chicken wire.

To this aim the forest garden was an initial exclosure although unfortunately hares have now breached the rabbit fencing.

"The main fruit trees have been in for four years and they have been planted in groups know as guilds. They have been planted so that they mature at different times which helps with memory, and the earliest maturing are planted at the farthest place. We would definitely recommend tasting apples before making the plunge to buy. We choose varieties with good scab and canker resistance. That said, the only apples we have been disappointed with are London Pippin and Falstaff on grounds of taste and the fact that the latter is known more as a juicing apple.

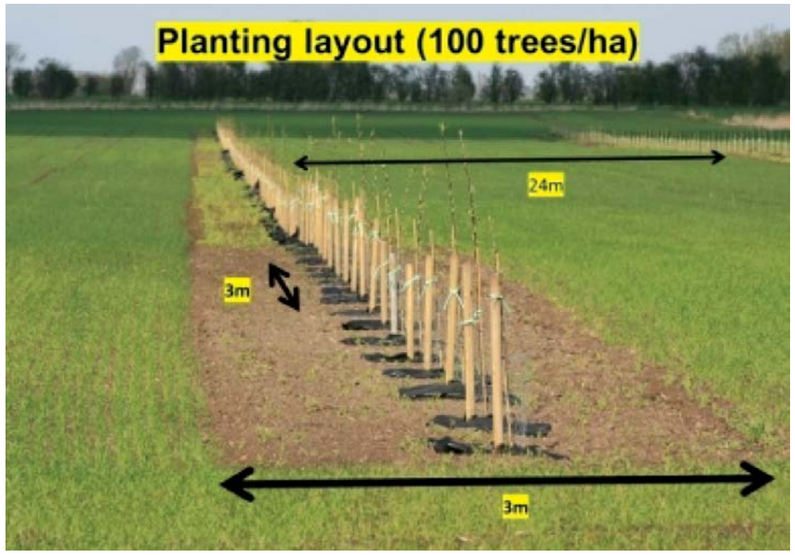
"Providing you are getting the harvesting at maturity correct, growing dessert apples where they are not in theory meant to grow can work. That said, they are sold through a box scheme and therefore reaching the consumer within 24 hours of harvest. My favourite eating apples are Katy, Woolbrook pippin, Sanspariel, Spartan, Saturn, Ellison orange, Ribston Pippin and Egremont Russett. We grow many varieties of pears and wish we had grown more. They seem to be more naturally tolerant of the damp. We have absolutely no problem growing cooking apples although sometimes it is hard to sell the gluts commercially. We have experience of growing the cob nut varieties in alleys in the vegetable fields, but in hindsight we wish we had just grown local hazelnuts varieties instead and had the double benefit of coppice (see chapter 6) and maintaining local genetic diversity. We cannot get commercial cob nuts to pass the water sinking test, suggesting that there is not enough sunshine in North West England.

"The understory across the forest garden is the next phase from 2020 onwards. We are going to bring in a digger to create ridges across the fields inside the apple guilds. The apple trees are planted further apart than in a commercial orchard as there is the space to do that. The ridges will be planted to two nitrogen fixers that are locally around in the wild – gorse and broom. I think looking at what is happening in nature is always a good start, and gorse and broom flowers are great for the bees. These will then provide the shade for a commercial crop of rhubarb which is realistic in terms of our time to harvest. Rhubarb does not like to be waterlogged in winter so the growing on ridges will assist with that.

"In the furrows, where the soil that is excavated, the plan is to grow wetland tolerant flowers like yellow flag iris, purple loosetrife, knapweed, yarrow, hemp agrimony, meadowsweet, cuckoo flower, marsh marigold, water mint, buttercup and ragged robin. Some of these will be suitable for cut flowers. I think the real task will be stopping the docks, nettles and brambles dominating in dry years. Under the south side of main trees, it is also possible to grow herbs for sale and we have a market for common mint, common thyme and rosemary that can be propagated relatively cheaply from seeds."

Fruit and nut trees may be planted on the edges of cultivated beds. Alley cropping is the planting of rows of trees or shrubs wide enough to create alleyways within which cultivated crops can be grown in a north to south direction. Stephen Briggs[92] recommends the cropping area is 24m apart

Promising edible alley crops that double as a wind break. Fruit trees can also stand proud of a traditional hedge.



Tree or shrub	Distance apart
Hazel	4 metres
Apples & Pears	3 metres
Cherry Trees planted on a 45 degree angle and pinned to the ground to allow netting	3 metres double rows staggered

8.4: Resources

The management options discussed will work best when there is a fencing "exclosure" of the outer boundary to keep out grazing herbivores (e.g. deer, rabbits and squirrels), who damage crops and young saplings. The British Deer Society offer advice around fencing (https://www.bds.org.uk/index.php/advice-education/deterring-deer). On vast tracts of land reintroductions of apex predators, like wolves or pine martens, could achieve the same and are aspired to by the rewilding movement.

Growing annual crops

Hall J and Tolhurst I (2005) Growing Green: Organic Techniques for a Sustainable Future. Vegan Organic Network.

Facebook page Woodchip for Soil Health

https://agricology.co.uk/woodchip-fertile-soils-woofs

This is Iain Tolhurst's collection of works.
http://www.tolhurstorganic.co.uk/back-to-earth

https://www.researchgate.net/publication/228364133_Ramial_Chipped_Wood_the_Clue_to_a_Sustainable_Fertile_Soil

https://www.cotswoldseeds.com/articles/227/guide-to-green-manures

Orchards and Agroforestry

https://www.agroforestry.co.uk

The Agroforestry Handbook by The Soil Association

Agforward - Best Practice Leaflets

Woodland Trust - Agroforestry delivers for nature and farming

Chapter 9
Conclusions

An international example of a marginal land without grazing herbivores with natural succession on the highlands and paludiculture for fibre and food in the lowlands.

Alternatives to Commerical Grazing is a call towards climate-friendly farming and nature recovery. This guidance offers a whistle-stop tour through all the management options and suggests broad alternatives with regard to peatlands, woodland management and food crops on marginal land. Nothing in farming can be assured to last for ever. However, a farming sector that concentrates on carbon sinks is a significant way to address climate harm and biodiversity loss. No longer will farmers have incentives to neglect the soils that are the basis of all food production. Civilisations have toppled before us due to the lack of reverence for nature, especially the soil.

It has become increasingly difficult to see how intensive grazing can continue once the Basic Payment Scheme is removed and the UK becomes wetter, as existing drainage systems are unable to cope. A clear message from the case studies is that it is better to be proactive ahead of the monumental changes that are set to happen to farming. We also must accept that to feed a growing UK, and indeed world, population, we have to reduce our consumption of animals. There simply has never been enough land for us all to achieve the western affluent diet. It is a diet that has too many externalities, related fossil fuel use, pollution and biodiversity loss. Even if the animals are is farmed organically, Simon Fairlie's work *Can Britain Feed Itself* suggests it requires too much land.[93]

So let us now move forward in the spirit of imagining a better future. Above all, the greatest joy will be the return of nature. As a culture we have lost this connection, a connection that shows what it is to be truly human. This connection can be found in a farmer's happiness in seeing the return of a snipe or curlew, the proliferation of the cotton-grass spectacular on restored peatlands and the dappled shade of woodland. It could well be that coppice and paludicrops become the backbone of a zero-waste circular economy with new opportunities for sawmills and eco-friendly building products. All farmers on mineral soils could experience the buzz from seeing earthworms return, a good indicator that everything else is working. Peatland farmers could achieve hero status at being the most effective carbon sink on the planet as their sphagnum mosses join together.

Finally, we must remove the taboo around farmers supporting plant-based agriculture. Plant-based diets from home-grown produce may just be what we all need. For the current author it conjures up images of her mum's root vegetable stew, apple pie and dandelion and burdock. This diet has been familiar and comforting for a very long time. We need to reimagine a farming sector that has shifted so that the climate can stabilise, species can return and everyone has access to a varied and health promoting plant-based diet, grown from crops on British farms.

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