Forest Gardens In the UK: A vision for 2030 based on concerns for climate change, diet and sustainable livelihoods

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Introduction

The overall aim of this short discussion paper is to contribute to knowledge on forest gardens and food forests in a manner that would help UK citizens to become more resilient to climate change and post COVID indebtedness.

The specific aims are to:

(A) Define the term forest garden in the UK and illustrate how the term is evolving

(B) Summarise what has been discovered from the scientific analysis of forest gardens relevant to the UK

(C) Highlight key findings from agroforestry that are relevant to forest garden optimisation

(D) Identify relevant, and simple measures of effectiveness that can be used by practitioners so that they can improve their resilience in the face of climate change, threats to wildlife and pandemics and

(E) Make recommendations for future initiatives linked to targets.

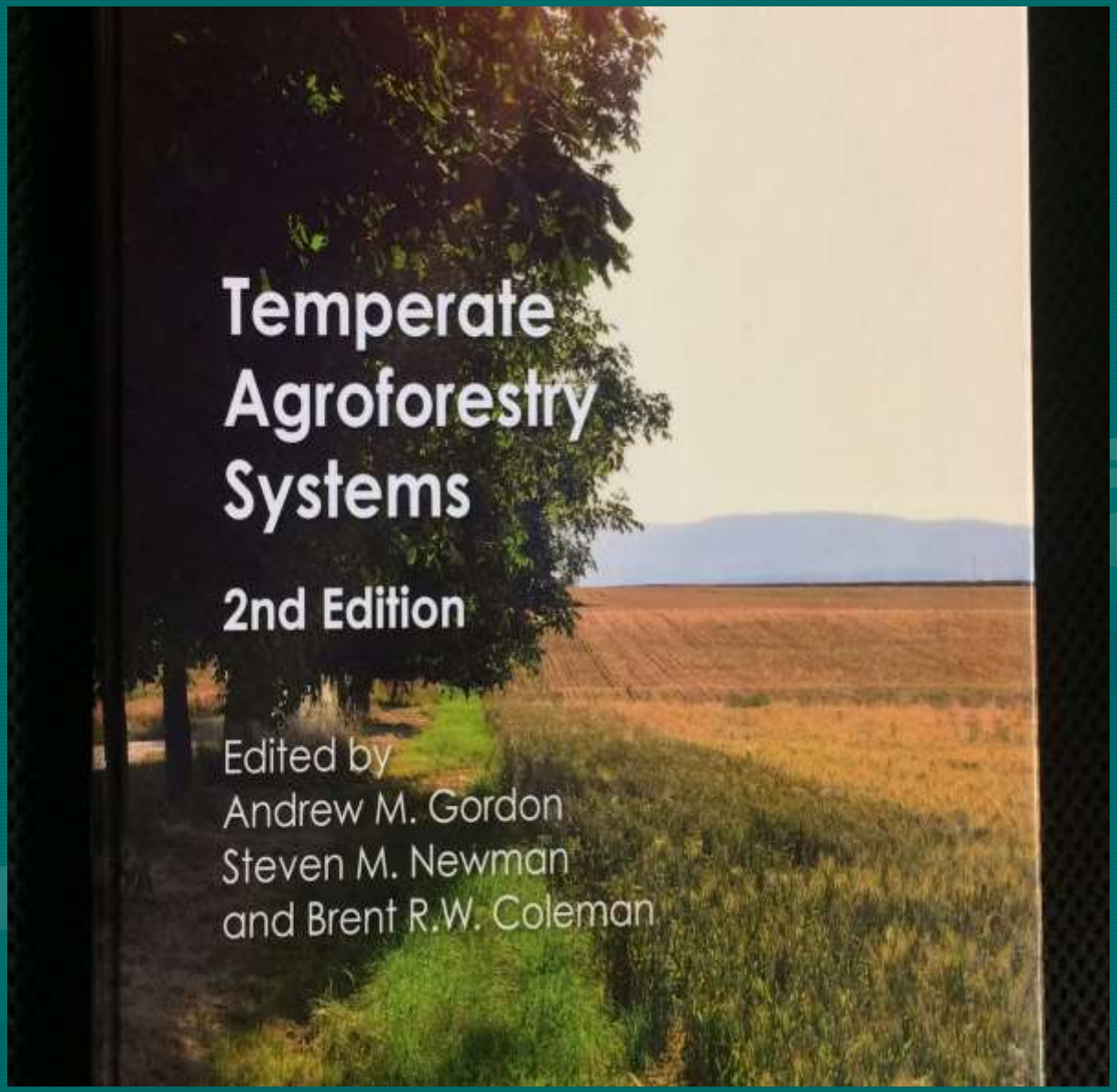
Sources

The talk is based on 40 years of temperate agroforestry research and development with emphasis on the UK, China and India.

Key references include:

1. Temperate Agroforestry Systems published by CABI

2. Soil Association Guidelines for UK Agroforestry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Edited by
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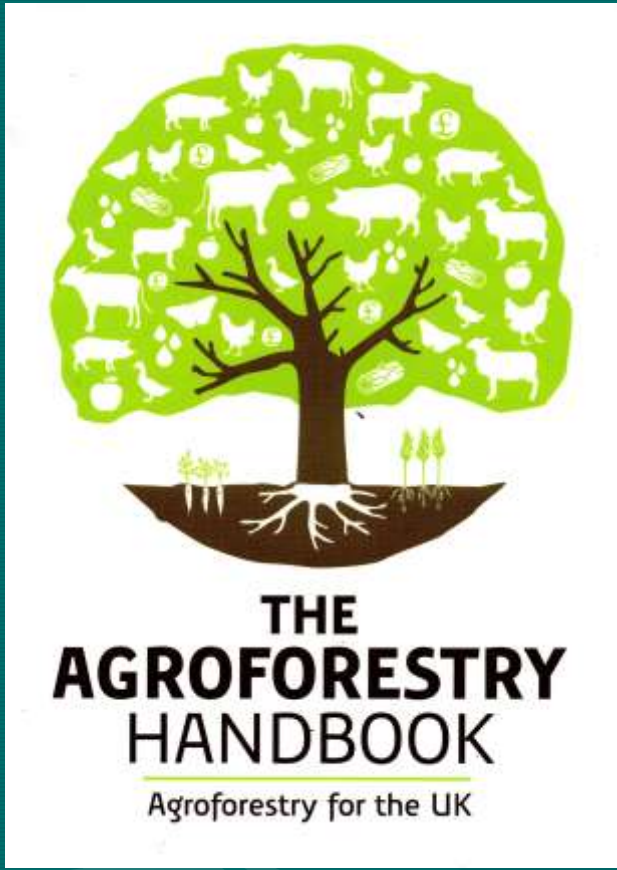
Steven M. Newman
and Brent R.W. Coleman

2018



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Evolution of UK forest gardens (1)

A search of CAB Abstracts using the terms forest gardens and UK yielded only 9 references. The oldest reference was for 1955. The paper referred to a forest garden in Crarae Scotland. This is a garden containing woody plants from the Himalayan region and forestry research plots

Interactions with Robert Hart over the period 1980 to 1991 led to an implied definition of a forest garden:

A garden consisting of at least 3 layers (tree, shrub and ground) with up to 80 species including trees that could produce good quality timber as a by product of nut production designed primarily for food production, with the potential to support a family of up to 10 people on an area of half a hectare. **This equates to 20 per hectare which can be referred to as the Hart Target**

In 2017 Thomas Remiarz published Forest Gardening in Practice and helpfully produced a simple definition:

Forest garden stands as a generic term for multilayer perennial plantings and for small scale and home gardens in particular

Evolution of UK forest gardens (2)

An appropriate definition that captures thinking in 2021 could be

Forest gardens are a form of agroforestry involving very-diverse (often more than 50 species) multilayer predominantly perennial plantings and sometimes animal production on a small scale for allotments and home gardens in rural and urban settings.

Principles of agro ecology (to increase yield and profitability and at the same time reduce the needs for agrochemicals) and community cohesion (synergy of people working together) can be used to make these systems resilient to the challenges of climate change, pandemics, and biodiversity loss.

When the practice is carried out on a larger scale such as in urban and peri urban settings it is often referred to as a food forest.

UK forest gardens

- The average number of species in a UK Forest Garden was 64 and that the size was 0.8ha on average (1). The size is big (40 times) the size of the average UK garden (0.02 ha) and (20 times) the size of the average UK allotment (0.04 ha)
- The average yield of a Forest Garden is very low (2) at 713 Kg dry matter. Calculations showed that this could provide 415,075 kcal of energy. This is equivalent to **0.9 tonnes per hectare** and 518,844 kcal per hectare. Nutritional analysis of the plants harvested showed that the garden was able to supply up to 7 males or 5 females with carbohydrate, 4 males or 5 females with fat and 3 males or 5 females with protein. The authors note that this could be potentially increased by incorporating more protein and fat crops such as legumes and nut trees.
- In conclusion the food yield is very low and less than half of the Hart target of 20 people per hectare. This represents a major opportunity for improving what could be called functional symbiosis (ecological combining ability) through using agro-ecological principles developed as part of intercropping and agroforestry.

Monoculture and maximum productivity

The UK 2018 potato crop averaged 41.7t/ha, however some fields yield above 80t/ha. Assuming 73% moisture this would give **11 dry tonnes per hectare** on average with 22 tonnes in some fields (could be achieved by a good gardener).

100g of fresh potato has a calorific value of 82 kcal which is equivalent to 820,000 kcal per tonne. Using the above 22 tonne data, this equates to enough energy to support **72 adults** assuming total digestion (100% food conversion) of raw potato.

Recent calculations on maximum theoretical productivity on the planet now give a figure **of 200 dry tonnes per hectare. (3)**

In conclusion the food productivity of UK forest gardens is 24 times less than a potato crop and 222 times lower than maximum theoretical global photosynthesis

70 adults supported per hectare by forest gardening or food forests is an especially useful target that would be a boon to creative thinking. If this is attained, then the average garden would support (0.02 x 70) 1.4 people or (0.04 x 70) 2.8 people.

Food energy and Land

We have the following options for food energy: (A) a tuber, a sallet, a grain, or (B) an oil from an oil seed (e.g., rape) or nut (e.g., walnut or hazel)

It is clear that a combination would give better nutrition. In agroecological terms where the energy comes from in terms of the tree layer or the field layer is a function of a plants, seasonality, and role in temporal partitioning.

Jill Edmondson and colleagues looked at the hidden potential of urban horticulture in 2020 (4). They used GIS in the UK and found 16000 square km of urban land with 50% classified as green infrastructure. They noted that this is 5.3 times larger than that used nationally for the commercial production of fruits and vegetables. On this basis food forests represent an ideal suggestion for urban and peri-urban areas

In terms of access by the poor, the best option is to develop partnerships that capture the land betterment value via the creation of forest garden villages (5).

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Carbon Negative Agroforestry Village on 30 acres "restoring nature and community" on 1000 acres

- 2,500 people housed in 455 dwellings on a 30 acre footprint
- Land and build cost £38.5m (agricultural land prices)
- Rental yield £10.9m (90% social housing target if hotels included)
- Vanishing point (loan repayment plus 20%) Year 5
- Potential partners include state land owners and pension funds
- Annual income to the community including agroforestry income of £582k is **£11.5m per year FOREVER**

Carbon sequestration

Schafer and colleagues in 2019 (6) looked at the carbon stock in the tree layer in Martin Crawford's mature forest garden and found about 40 tonnes Carbon per hectare above and below ground using allometric equations.

Lehman and colleagues in 2019 (7) looked at the carbon stock in the understory layer in Martin Crawford's mature forest garden and found about 4 tonnes Carbon per hectare giving a total of 44 tonnes (above + below ground) using allometric equations. The 4 tonnes in the understorey were a notable addition.

Assuming an establishment date of the garden of 1994 this represents an accumulation of 1.76 tonnes per hectare per year which is particularly good. It has been estimated that UK forestry and grasslands sequester 110±4kg and 240±200kg of carbon per hectare per year respectively, whereas croplands lose on average 140±100kg of carbon per hectare per year (8).

The challenge for forest gardeners is to identify which systems and forms of management lead to a more permanent store of carbon. Ponds and boggy areas may offer the greatest potential.

Agroforestry approaches relevant to forest garden and food forest optimisation. (1)

1. For complex farming systems think of them as simple subsystems e.g., binary mixtures.

For instance, a chicken will benefit from high calcium in the leaves of Hazel. In return the Hazel may benefit from the phosphate in Chicken dung. For apple with wild garlic, the garlic may benefit from shade and the apple may benefit from scab reduction linked to volatile oils arising from the garlic if disturbed on a hot day.

2. For measuring the level of functional symbiosis consider three agronomic measures of effectiveness.

If you know that walnut produces 5 tonnes a hectare as monoculture and so does wheat. You have not saved any land if you mix then on the same hectare and get 2.5 tonnes of each. I grew pear and radish together and obtained a full yield of each, so I got a land saving of 100% (9). In other words, twice as much land is required to obtain the same yields from monoculture. This calculation is known as the land equivalent ratio and is used for combined crop yield.

If I have a choice to feed my chickens on (A) a field of wheat and get 2 tonnes of feed per hectare, or (B) under mulberry trees and get 1 tonne of feed per hectare or (C) use mulberry wheat agroforestry and get 2.5 tonnes of chicken feed I will choose option (C). The mixture gives a higher yield than the best monoculture. This is known as the feedstock yield calculation.

If you want to carry out forest gardening on a farmer wheat field and he is sceptical about adding walnut trees, then agree with the farmer that it is only a good idea if he can still get the same or higher yield of wheat if the trees are added. This is known as main crop yield and in this case, wheat is seen by the farmer as the main crop. The converse situation may be considered if walnut is the main crop for an orchardist and the farmer is sceptical about intercropping wheat.

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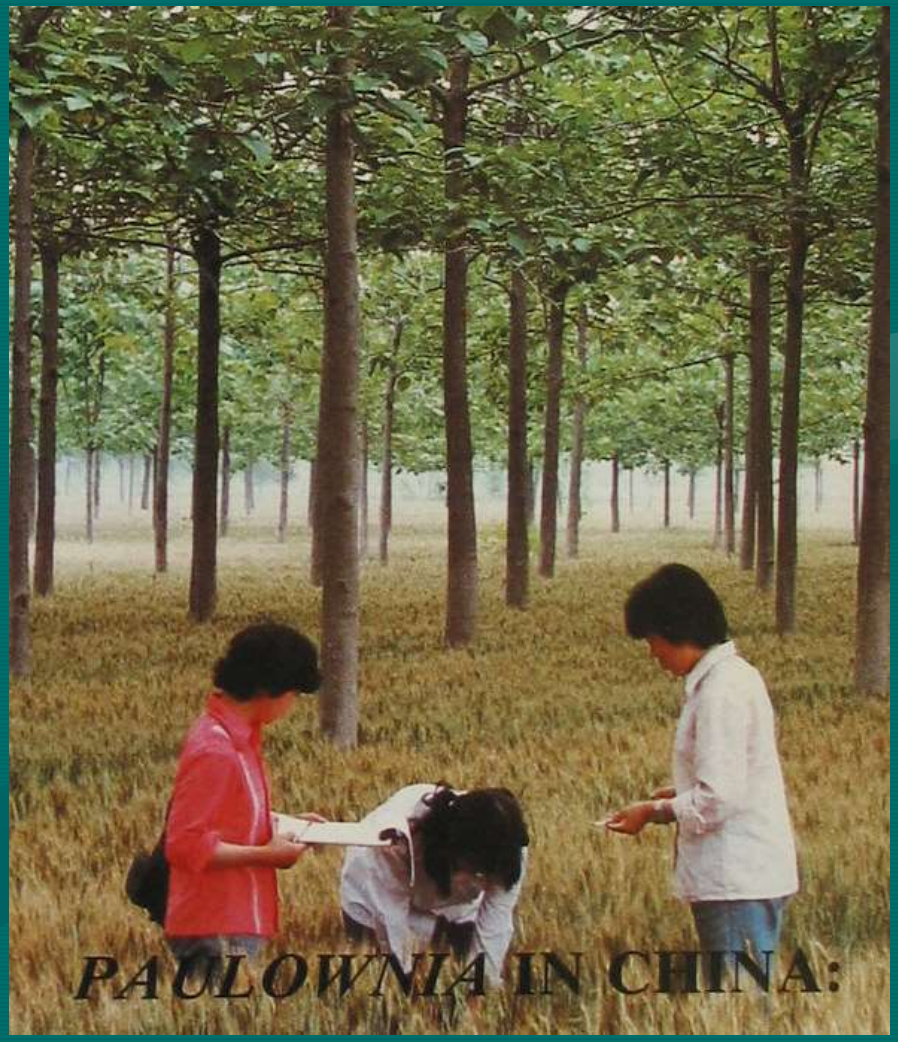
Agroforestry in China

- No loss of crop or tree yield (no of high value stems) when combined.
- Twice as much land needed if monocultures used
- Irrigated so light is a limiting factor.
- Cereals develop before the tree canopy and shade tolerant intercrops follow
- Carefully selected trees and crops share multidimensional niche space



Approaches from agroforestry that are relevant to forest garden and food forest optimisation. (2)

(3) For designing systems think of three agroecological mechanisms to optimise functional symbiosis

The first mechanism is partitioning or sharing. This where one component uses resources from a different space than the other component. E.g., the tree uses phosphate deep in the soil in a place where a shallow rooted crop cannot get it. It also can happen in time for instance if a radish plant takes light before the leaves of a pear tree come out. This later mechanism is called temporal partitioning, and this is a most important mechanism in multi-layered systems.

The second mechanism is called synthesis where one component causes a chemical change in the environment of another component e.g., a legume chemically transforms nitrogen in the air and makes it available as a nitrate to a non-leguminous plant.

The third mechanism is called modulation, and this is where one component causes a physical change in the environment of another component e.g., a maize plant provides a support for a climbing bean or a tree protects the understorey from a damaging wind.

Approaches from agroforestry that are relevant to forest garden and food forest optimisation. (3)

(4) For temporal partitioning think of opportunities linked to seasonality in the UK context

Deciduous trees offer great promise in forest gardens as some species such as walnut or mulberry are late leafing. It may be effective to combine understorey plants that grow during the period when the tree has no leaves and ideally can tolerate cold. This could include oil seed rape, dandelion, goosegrass etc.

(5) For the tree storey think of maximum food production per unit leaf area duration

The leaf area duration of ash is low, and the tree produces excellent leaf fodder.

(6) For the field layer think of maximum food production per unit light (Photosynthetically active radiation) and going with the flow of plant response

Parsley will increase above ground dry matter production with moderate shade. A classic shade response of plants is increase leaf area so choose understorey plants where the leaf is the economic part e.g., mint. Permanent pastures are also resilient to periodic shade

Permanent Pasture

Moderate shade increases above ground biomass

Approaches from agroforestry that are relevant to forest garden and food forest optimisation. (4)

(**7) For arranging and selecting trees consider a canopy cover of less than 20% when the trees are giving full yield**

This is easily achieved by wide spacing, pruning and or using espaliers or other slim or columnar forms of trees.

(8) Do not discount annuals.

The term annual does not necessarily mean that soil cultivation is always required. Direct drilling is a powerful technique. The concept of perennial wheat and perennial potatoes should be explored.

(9) Shade trials can be inexpensive and highly informative.

Radish can be shaded by 50% without affecting its yield as a fodder crop. Potato can tolerate up to 26% shade (10). It should be noted that this tolerance was achieved using standard varieties so better tolerance can be expected by selecting or breeding appropriate varieties. it is well known that some flavours and essential oils are increased in plants that are shade compared to those grown in full sun.

(**10) Consider using plants in containers** as a strategy for learning and alternative management.

Growing plants and small trees in containers gives great flexibility and can improve yield and precocity. It can be useful in finding out about whether key environmental interactions (above or below ground) are important in giving rise to positive or negative effects in a forest garden. I used this technique to optimise pear and radish agroforestry and using crops (11) to identify key environmental factors is known as the phytometer technique (12)

Radish under shade (100%, 50%, 70%, 10%)

- 50% light gives the same total biomass as 100% light
- Some individual plants in 50% give same shape as 100%

Other measures relevant to forest gardens and food forests

For one hectare within 3 years. (Independently verifiable baselines would be required)

Social capital: the number of friends and useful advisors that a person has access to without cost doubled.

Financial capital (1): Total income per hectare from the garden minus costs greater than the minimum wage £8.91 per hour which is £17143 per year based on 52 weeks of 37 hours.

Financial capital (2): Cost reduction on food purchases by at least 50%

Financial capital (3): Level of indebtedness reduced by at least 50%

Recommendations: The "Hart Challenge" 2021

70 adults supported per hectare should be the target along with the targets in social and financial capital

Monitor forest gardens and food forests could be used as exemplars

These should have open accounts and be a replicable model for learning and extension purposes. It should be eligible for government and or funding and champions should be recognised and appreciated using award schemes. It could take advantage of local landscape features and mature trees.

At the garden scale

Monitor forest gardens established and recognised with the dominant caloric staple to be any of the following.

- A tuber
- A nut tree.
- A grain crops.
- A sallet crop

At the landscape scale

Monitor food forest at the 1000-acre scale with housing one 30 acres achieving the same targets as above plus agreed biodiversity and carbon sequestration targets that could be monitored and verified by a lay person.

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Thank you

Any questions please?