Woodland Trust Research Briefing

Elm Farm: Planning and developing agroforestry at a farm scale

Sally Westaway and Jo Smith, Organic Research Centre

December 2019

Contact research@woodlandtrust.org.uk

Summary:

The term agroforestry encompasses a wide range of different approaches to integrating trees and farmland. Over a 10 year period a range of agroforestry approaches have been introduced to Elm Farm, including making better use of existing resources (boundary hedges and trees); planting new landscape features (e.g. hedges, in-field trees, tree avenue) and implementing a new bioenergy alley cropping system.

Because Elm Farm is was both a commercial and research farm, it offered the opportunity to collect data and monitor establishment in a commercial setting. This research briefing outlines the planning, establishment and management of these different agroforestry approaches. Key results and lessons learnt are:

- **Detailed planning is important. Consider carefully which species are appropriate and consider trialling a few in advance of large-scale planting.**
- **Controlling competition from weeds and grasses is essential for promoting better tree establishment. Using woodchip mulch from on-farm or a locally available resource was found to be the best option.**
- **Fencing is essential to protect newly planted trees and coppice regrowth from livestock; one strand of electric fencing was enough to keep cattle away, while at the same time allowing them to reach grass in the understorey of the tree row. Deer damage was present but not widespread; where deer pressure is high more robust fencing and deer management will be required.**
- **Farming operations, both current and future, need to be considered including any site-specific restrictions on accessing the trees (e.g. seasonally waterlogged soils) which may affect management and machinery sizes to fit around the trees.**

Figure 1: Panorama of Elm Farm showing the existing hedgerows and newly planted in-field trees.

Introduction

Agroforestry (i.e. combining trees and agriculture) is an effective land use approach that maintains or enhances the productivity of a farming system while supporting ecosystem services including soil and water protection, biodiversity, carbon sequestration and social benefits such as rural job creation, recreation and a beautiful landscape. Agroforestry includes both the establishment of new trees in productive fields and the integration of existing boundary hedges and trees into the farming system. The emphasis is on managing rather than reducing complexity, and as such, it is knowledge intensive, with farmers and growers needing to work with their environment to create a dynamic, ecologically based, natural resources management system that offers more resilience in the face of future climate uncertainty.

Trees are a long-term investment and, as every farm is unique, careful planning is needed to get the right systems in place and to maximise the multiple potential benefits of having trees on farm.

Over the last 10 years 3,800 new trees have been planted and new management approaches for the existing trees and hedgerows have been introduced to Elm Farm in Berkshire as part of a farm-scale agroforestry plan to increase the overall productivity of the farm whilst also providing environmental benefits. This research briefing outlines the process of planning, establishing and managing this range of agroforestry systems, lessons learnt, and data collected along the way.

Agroforestry at Elm Farm

Elm Farm is a privately-owned 85 hectare organic livestock farm in West Berkshire and was the base for the Organic Research Centre from 1980 to 2019. Originally a dairy farm, then managed by a local tenant farmer to raise young dairy stock and beef cattle for 15 years, in 2018 the cows were replaced by sheep as part of a new share farming arrangement. The soils are mainly Wickham Series poorly drained clay loams, susceptible to structural damage which limits the range of agricultural activities. The farm sits within a wooded landscape in the North Wessex Downs Area of Outstanding Natural Beauty, bordered by three small woodlands and a neighbouring estate with beautiful parkland. The farm has approximately 9.5 kilometres of large traditional mixed species field boundary hedges. The average annual rainfall for the area is 672 mm, average annual minimum temperature is 6.9 °C and average annual maximum temperature is 14.6 °C.

Agroforestry approaches introduced to Elm Farm over the last 10 years include:

1) Managing hedgerows for bioenergy production. Since 2013 we have been investigating the potential of managing traditional field boundary hedgerows to produce woodchip for bioenergy, while maintaining their environmental and cultural values[1,2,3].

2) New tree planting. In 2014 the Woodland Trust supported three new tree and hedge planting schemes on the farm: a tree avenue with fruit and timber trees, bioenergy field boundary hedges and in-field standard trees.

3) Integrated bioenergy and livestock production. An innovative alley cropping system integrating short rotation coppice for bioenergy with livestock production was established in 2011[5,6].

Figure 2. Managing hedge for bioenergy production (a) coppicing a hazel hedge at Elm Farm in 2015 (b) hazel coppice regrowth after six months

Figure 3. New tree planting at Elm Farm (a) biomass hedge (b) the tree avenue (c) in-field trees

Figure 4. Integrated SRC bioenergy and livestock alley cropping system at Elm Farm (a) multi-species ley in 2019 (b) SRC alder harvest from 2018

Planning, planting and establishing new agroforestry systems

Agroforestry aims to harness the ecological and financial benefits of combining trees and agriculture. When planning a new hedge or agroforestry planting it is important to consider how the trees can be planted to maximise those benefits. The first step is to look at existing trees and hedges on the farm, their current functions (e.g. shade/ shelter, a resource for wildlife) and decide what further functions you desire. the next step is to assess whether changes in management of existing features could be beneficial and how any new tree planting could help.

At Elm Farm the large field boundary hedges represented a significant underutilised resource and required management. Coppicing to produce woodchip for bioenergy was proposed as a technique that could both restore the hedges while providing some financial gain to the Farm.

Given the existing woody resources on the farm why did we then seek to increase tree cover? In discussion with the tenant farmer, we identified many reasons to plant trees, including improving the farm business and rural economy, improving the environment and supporting our research and knowledge exchange activities.

The new tree planting and agroforestry alley cropping systems were planned around the existing trees and hedges, to fit with the agricultural system and management constraints, test novel planting designs and sought to use underrepresented species as well as those that were known to be suited to the Farm. . The aims were to increase the diversity of trees and hedges on the farm both in terms of species but also in terms of tree growth stages and to investigate how trees could increase the resilience of the farming system via the environmental services and resources (e.g. fuel or fodder) provided.

Figure 5. Aerial view of Elm Farm in late summer 2018 showing the Integrated SRC bioenergy and livestock alley cropping system.

Bioenergy from traditional boundary hedges

Despite increasing interest in managing hedges for woodfuel, there is limited data regarding the productivity, logistics and potential impacts of such management. Here we outline the results of trials carried out Elm Farm to address this 1,2,3. At the start of the trials in 2013 most hedges at Elm Farm had not been actively managed for many years, aside from occasional side flailing. The total length of hedges on the farm is approximately 9.5 km. The most common species are blackthorn (Prunus spinosa), hawthorn (Crataegus monogyna) and hazel (Corylus avellana), often with scrubby outgrowth. An initial hedge survey identified that approximately half would be suitable for coppice management. Trials were then established to assess different coppicing methods, the biomass productivity of different hedges, woodchip quality and the impacts of coppicing on hedge ecosystem service provision.

Results

Five different hedges were assessed. The average yield of woodchip was 8.1 tonnes per 100m at 30% moisture, with a large range (5.5t to 13t) depending on the dominant species and the age of the stems at harvest.

Table 1. Biomass yields per 100m from different hedge types at Elm Farm

Hedge type (dominant species)	Years since last cut	Biomass (t/100m @30% mc)
Hazel	28	6.3
Blackthorn	40	13.0
Hawthorn	40	8.2
Hazel	15	5.5

These yields were from unmanaged hedges brought into a new coppice management cycle; future yields will vary depending on species and coppice rotation length. A considerable amount of time is needed to get old hedges ready to coppice (removal of outgrowth, old fence lines etc.) and the labour effort for management should reduce once a rotation has been established. Regrowth rates and response to coppice management varied between hedges and species - hazel, willow, field maple and hawthorn all responded positively to coppice management. Blackthorn regrowth was slower and often from underground suckers.

The presence of long shards and slithers is one of the biggest issues with hedgerow woodchip and some of the hedgerow woodchip samples failed to pass standard tests for woodchip quality on this criterion. However, all samples passed for all other tested criteria and all woodchip from Elm Farm was sold into a commercial woodfuel hub. The type of chipper used (small or large fuel grade) made only a small difference to overall chip quality. Both harvesting and chipping costs per metre were calculated by dividing the day rate by the number of metres of hedge each machine can harvest or chip in one day. The average cost to coppice and chip one metre of hedge was £5.67 (range £2.26 to £9.90). The energy cost of hedgerow woodchip ranged from 1.6 to 3.5 pence per kWh depending on machinery options and hedge type[1,2,3].

Management considerations

Consideration should be taken, especially when coppicing, of connectivity and the role that hedges play in the landscape. A biodiversity protocol4 has been developed based on the work at Elm Farm which enables landowners to assess their resource prior to any new management activities. It identifies hedges suitable for coppicing, those of potentially high biodiversity value as well as those in need of improvement and offers general management recommendations based on different indicators. Where possible hedge management should be left until late winter to maximise the food resources available for wildlife.

However, the heavy soils and poor drainage across much of Elm Farm mean that management activities were best planned in late autumn/ early winter. Soil conditions can also be a limiting factor when considering which machinery is most appropriate.

Stools were protected by the existing livestock fencing but browsing damage on the coppice regrowth was low with a notable preference for hawthorn from the local deer population.

New tree and hedge planting

Working with the Woodland Trust, in 2014 we developed three schemes to fully integrate trees within the farming system and to complement Elm Farm's existing hedges and woody features:

a) A tree avenue planted alongside a popular public bridleway to provide a productive landscape feature and a link between woodland patches (sweet chestnut, pedunculate oak, field maple, rowan, hornbeam, cider and dessert apples, pear and quince).

b) Fifty trees planted within four fields to create the next generation of parkland trees, as well as produce timber and tree fodder, provide shade and shelter for livestock and a resource for farmland biodiversity (pedunculate oak, small leaved lime, walnut, sweet chestnut, hornbeam, sycamore and white willow).

c) Over 500m of new hedges planted with fast-growing species to increase landscape connectivity as well as provide a source of renewable energy for on-farm use, and shade and shelter for livestock (hazel, white willow, sycamore and sweet chestnut with standard trees oak, hornbeam, walnut).

Figure 6: Multi species tree avenue. Photo:

Figure 7: In field trees at Elm Farm in stockades. Photo:

Figure 8: New bioenergy hedges at Elm Farm. Photo:

Tree and hedge planting and establishment

The hedge and tree avenue trees were planted in March 2014, with weed control using biodegradable mulch mats and woodchip. Half of the trees had 1.2 m biodegradable moulded fibre guards, the other half had 1.2 m standard plastic tubes. The in-field trees were planted in March 2015 after the installation of robust and costly tree stockades (£87 each including materials and labour) to protect the new trees from cattle. Stockades were 1m2 and 1.8m high with four round corner posts, two half round rails and stock netting.

All trees were 40-60cm one-year old bare root transplants, except the oak which were two years old, the sweet chestnut and the walnut which were seedlings and the fruit trees in the tree avenue. Fruit trees were planted in groups of at least five to aid pollination. Cider and dessert apples were maiden trees mostly on M25 rootstocks with five apple varieties on MM106 rootstocks.

The four new bioenergy hedgerows were planted as a double row of fast growing non-thorny species, with 50cm spacing, and standard trees were included at 20m spacing. One of the new hedges was planted as a trial with 20m single species blocks of hazel, willow, sycamore and sweet chestnut, the other hedges were mixed species.

Management considerations

The area around the base of each tree was mown in the first two years and new woodchip was applied. Fruit trees were pruned in February 2016. Mortality rates were relatively high in the first two years (20% in the tree avenue, 12% for the in-field trees and 6 in the hedges), particularly for sweet chestnut planted in the hedge with Ezee tree guards (20% mortality), most likely due to a lack of light as they were planted as seedlings. In 2016, most of the rest of the sweet chestnut died as well as one variety of apple and some of the oaks. Factors for this high mortality include weed control, the heavy soils and unsuitable species and varieties. All dead trees were replaced with species better suited to the farm. White willow trees were used to replace dead trees in wetter areas, which in future years may provide a source of tree fodder for livestock.

The fibre guards appeared to suppress weeds better than the spiral guards. This is again likely to be due to limiting light conditions. However, following wet weather, the base of the fibre guards began to degrade and within two years the entire guard had dis-integrated and they were replaced.

The biggest challenge with the in-field trees was providing adequate protection against livestock. The stockades were expensive but effective, and to date, have needed no maintenance. However, they restrict access for management and in some cases, have been colonised by weeds. The stockades also make tractor manoeuvres around the trees for hay or silage cuts more challenging.

Figure 9: New hedge planting at Elm Farm using Ezee tree guards and standard spiral guards. Photo:

Integrated bioenergy and livestock agroforestry trial

A replicated plot trial combining Short Rotation Coppice (SRC) with cattle production was established at Elm Farm in April 2011 using an alley-cropping design with tree rows running north/south. The aim was to provide a resource for the farm (bioenergy and fodder) as well as financial and environmental data on establishing and managing an agroforestry system which combines trees for bioenergy with agriculture.

Planting and establishment

Trees were planted in twin rows, 0.7m between twin rows and 1m between trees, with an initial density of 1,000 trees per ha. Willow (Salix viminalis) was chosen as it has a dual value as both a bioenergy source and a livestock fodder. The second species was common alder (Alnus glutinosa); its value as a fodder crop is unclear, however it fixes nitrogen and coppices well. Three non-chemical weed control options were trialled; direct planting into pasture (the cheapest option); woodchip mulch (using local woodchip) and a fabric mulch barrier (the most expensive option; a jute version and a black propylene version were trialled).

In the first two years the bare-rooted alders established better than the willow cuttings. Spring 2011 was much drier and warmer than usual and, combined with competition from the existing sward and deer damage, it seems likely that this affected the willow cuttings more than the alder saplings. Tree survival was significantly higher in the plots with the jute fabric mulch for weed control, compared with direct planting into the grass sward (Figure 10). About two-thirds of the trees were replaced in the following winter. In 2012, tree survival was similar within the woodchip and black propylene fabric mulch plots. By 2013 willow and alder survival rates were not significantly different, although by 2015, alder trees were significantly taller than the willow.

Management considerations

Dead trees were replaced, all established trees cut back to 15cm aboveground, and woodchip applied to all plots in March 2013. A silage cut was taken once or twice a year for the first four years, and cattle were introduced in August 2015 for two months with a single strand of electric fencing appearing effective in keeping the cattle out. First harvests of the SRC started in spring 2016, with a third of the rows cut in 2016, 2017 and 2018. A diverse sward mix was established in autumn 2018 and grazed by sheep during the summer 2019.

To fit the equipment used for pasture management the alleys were initially 12 m wide between the centre of the tree rows. However, two years into the trial, following difficulties manoeuvring machinery, alleys were widened to 24m by removing every other tree row.

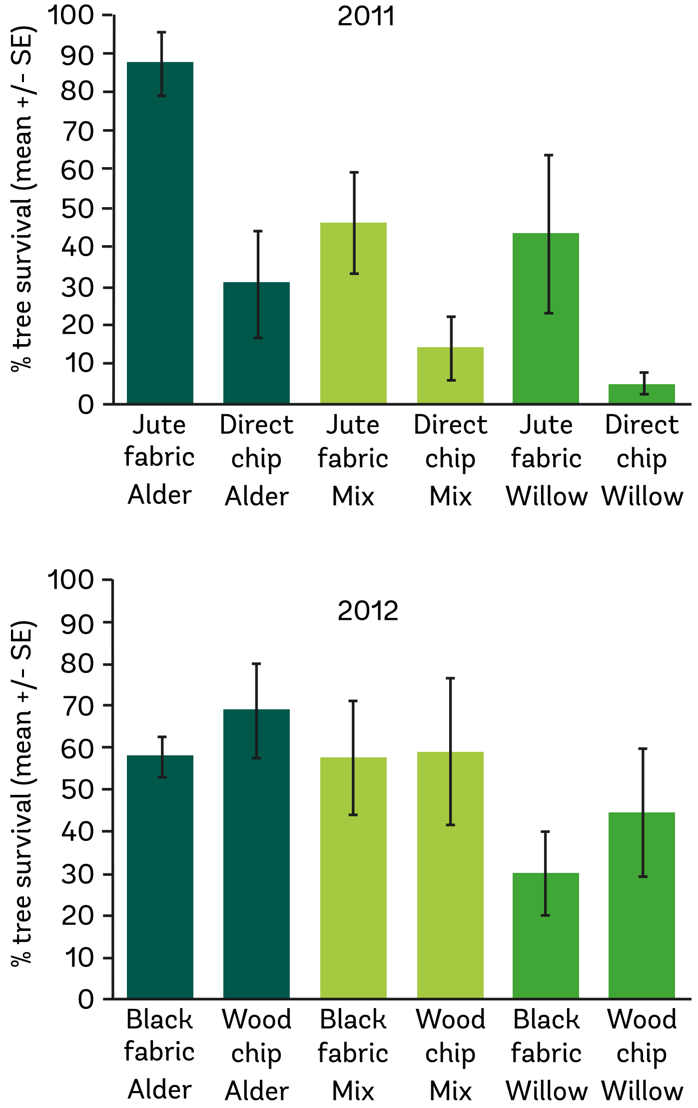

Figure 10: Tree survival the first two years following planting with the different weed control treatments

Table 2: Comparison of first harvest yields from Elm Farm willow and alder agroforestry against standard figures for SRC willow

	Woodchip yield oven dried (OD) kg/tree	
	2017 (4 years growth)	**2018 (5 years growth)**
RC willow standard figures (Nix, 2014)	0.67 to 1.33	
Elm Farm SRC willow	0.03	0.26
Elm Farm SRC alder	0.61	1.01

Results

Pasture productivity in the agroforestry rows varied considerably over a five year period (mean 2330 kg DM/ha) with the highest production in 2014 following a wet winter and spring, but there were no statistically significant differences found between the agroforestry plots and control plots with no trees, indicating that for the first five years, the impacts of tree planting on pasture productivity were minimal[5,6].

Willow yields in the agroforestry system were much lower than standard figures for SRC willow (Table 2); this may have been due to browsing pressure, weed competition or low fertility rates/ unsuitable varieties. The Salix viminalis varieties used were specific bioenergy varieties, while the native Salix alba planted in the hedges established well attaining heights of 2-3m in the first two years suggesting it was better suited to the farm. Alder yields compared more favourably with standard figures, which may reflect the N-fixing ability of alder compensating for the lack of additional fertiliser

Figure 11: Harvesting and measuring SRC from the integrated bioenergy and livestock agroforestry trial

General tree establishment

- Both fabric mulches fell apart quite quickly, with weeds and grass growing through the mulch and there was some evidence of animals digging and tearing apart the fabric.
- Deer preferentially browsed hawthorn hedge coppice regrowth and browsed the newly planted willow in the agroforestry. Cattle showed a preference for willow, but over time the cows adapted to browsing alder trees too. Controlled browsing of SRC or hedges could be one way to balance production of bioenergy with livestock production.
- Trees were planted directly into the existing grass sward and survival rates may have improved if planted into bare soil. Sub-soiling might also have been beneficial, particularly in areas where compaction was evident.
- Where woodchip is available it offers a cost-effective approach to weed control in newly planted hedges and agroforestry systems. Woodchip application with a feeder wagon is less labour intensive than laying mulches. However, at Elm Farm the timeframe for woodchip application is narrow, the ground is too wet to support the weight of a tractor for most of the winter, and by the time it had dried out, the grass was almost ready for ensiling.

Agroforestry system outputs/ diversification opportunities

The systems outlined in this research note demonstrate different approaches to utilising and increasing the woody resources on the farm which both enhance the ecosystem service provision of the farmed landscape and provide resources for the farm business including:

- Woodchip for bioenergy, livestock bedding or compost/ mulch
- Tree fodder – cut and dried, or directly browsed
- Shade and shelter for livestock
- Biodiversity, carbon, soil and water management

Conclusions – which system is best?

This will depend on the farming system in question, the presence of existing trees and hedges, the farm priorities and tree products/ benefits desired. For example, in an area where straw is not readily available, the bioenergy hedges at Elm Farm might be coppiced and chipped for livestock bedding.

At Elm Farm, with appropriate investment, the systems established would allow the farmhouse and buildings to be entirely self-sufficient in fuel, while also providing potential sources of tree fodder, woodchip for animal bedding and increased shade and shelter for livestock therefore increasing the resilience of the farm business. The environmental benefits include increased biodiversity on the farm, increased carbon capture and storage and soil protection. Pound for pound in the short term, management of existing resources is likely to be more cost effective than planting new trees as the resource is readily available and many trees and hedges on farms are in need of active management. However, planting new trees offers an opportunity to increase the diversity of species on the farm and to choose species and planting designs for specific purposes.

Further practical guidance on all aspects of agroforestry can be found in the Agroforestry Handbook. https://www.soilassociation.org/farmers-growers/technicalinformation/agroforestry-handbook/

Recommended citation:

Westaway, S and Smith J (2019) Elm Farm: Planning and developing agroforestry at a farm scale, Woodland Trust Research Briefing X

Acknowledgements:

We would like to thank all the people involved for all their help and support with these trials in particular Bob Winfield, John Handy, William Hamer, Matthew Prince and all the ORC interns

References:

1. Chambers, EM, Crossland, EM, Westaway, S, and Smith, J. (2015) A guide to harvesting woodfuel from hedges. The Organic Research Centre www.twecom.eu https://zenodo.org/record/2641806#.Xd5HuNXgrlU
2. Westaway, S, Chambers, M, Crossland, M, Wolton, R and Smith, J (2016). Managing traditional hedges for biofuel. 12th European International Farming Systems Association Symposium 'Social and technological transformation of farming systems: Diverging and converging pathways'. Harper Adams, UK http://ifsa.boku.ac.at/cms/fileadmin/IFSA2016/IFSA2016_WS32_Westaway.pdf
3. Westaway, S, and Smith, J (2019) Productive hedges: Guidance on bringing Britain's hedges back into the farm business. The Organic Research Centre. https://zenodo.org/record/2641808#.Xdv2WNXgrct
4. Crossland EM, Westaway S, Gerrard C and Smith J (2015) Hedgerow Biodiversity Protocol 2015. User Guide. A protocol for monitoring the impacts of harvesting hedges for woodfuel. The Organic Research Centre. http://tinyurl/TWECOM
5. Smith, J, Gerrard, C, Zaralis, K and Padel, S (2016). Assessment of an agroforestry system in terms of feed supply and multifunctionality. Part 2: Establishing a novel system. Deliverable for FP7 project Sustainable Organic and Low Input Dairying. www.solidairy.eu
6. Smith, J, Whistance, L, Costanzo, A and Deremetz, V (2017). Lessons learnt: agroforestry for ruminants in England. Report for H2020 project AGFORWARD. www.agforward.eu https://www.agforward.eu/index.php/en/agroforestry-with-ruminants-uk.html