Small-scale forestry for bioenergy consumption – Part I: Important tree species for consideration

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- Planting areas of woodlands is a great method to increase carbon capture, supported by a number of grants and incentive schemes
- Mixed tree species plantations result in improved disease and pest resistance, increased biodiversity of flora and fauna, and more resilient economic returns than monoculture plantations.
- There's a wide choice of both broadleaf and conifer tree species to consider, each with a range of end-markets and specifications, producing a timber supply for biomass, paper pulp, furniture and building construction.

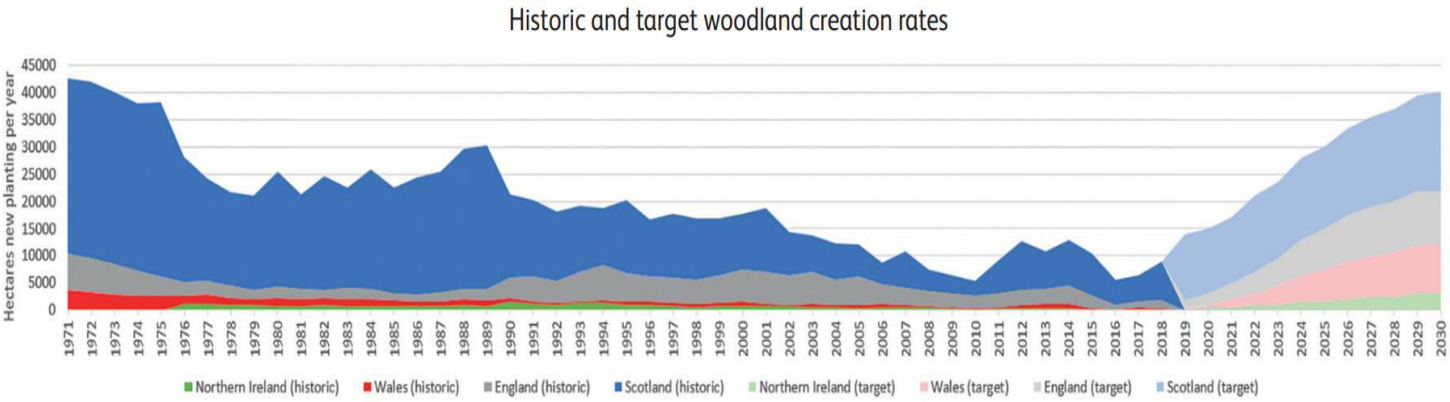
Previous 'Farming Connect' articles have explored the benefits of planting trees and hedgerows with regard to biodiversity, flooding, livestock and environmental impact. Here we explore the further potential for trees and hedgerows concerning bioenergy production. This article discusses a selection from the wide range of tree species often cultivated in agroforestry for biomass.

The importance of tree plantations for biomass

Producing bioenergy and bio-products from commercially cultivated biomass crops is just one part of a critical solution to reduce pressure on fossil fuels and reduce carbon emissions. The production of forestry on both a large or small scale is one of the strongest methods to tackle carbon emissions. Woodland creation reduces the carbon footprint in a number of ways:

- sustainable management, including timber farming, accelerates carbon sequestration in the soils;
- carbon in timber products, such as architecture and furniture, is locked up for longer;
- timber substitutes carbon-intensive alternatives;
- home-grown timber relieves pressure on global forests;
- end-of-life wood products can be recycled (biomass, biochemical and chipboard).

Forestry sectors across the UK are under demand to expand due to growing markets for home-grown timber, amidst requirements to enhance forestry ecosystems and habitats. The UK forms the world's second-largest importer of forest products, with £8.5 billion worth of wood imported from overseas in 2021. With 3.24 million hectares of woodland, only 13% of the total land area of the UK is under forest cover.



Historical and future target woodland creation rates from 1971-2030. *Graph from confor.org.uk*

Where is our timber material going to come from?

Although most of the UK timber resources are currently imported, there is increasing interest and demand in home-grown and environmentally sustainable timber, for both downstream production and increasing biomass demand. The percentage of UK woodlands has largely decreased in the past 30 years, as although more cultivated areas are added each year this is often balanced by woodland area being permanently removed for more appropriate habitat restoration to specific land type and approved development. To cope with increased demand, more woodland is required and the UK government wish to support development. An improved trend towards increased woodland creation can be observed, with approximately 2,300 hectares of new woodland development established in England alone between 2022-2023 absorbing around 600,000 tonnes of CO_2 by 2050.

Multiple tree species may be cultivated for timber and bioenergy production, and for habitat creation. There is something to be said for utilising native tree species, rather than imported species, as they are often better suited to the surrounding environment and climate, and it reduces concerns about invasion and competition with the local ecosystem. Several potential tree species for consideration are listed below:

Willow

Willow is a popular consideration for woodland plantation, and confers a high tolerance of wet or marginal lands. There are approximately 400 different willow species, of which the most commonly used for managed woodland systems are the common osier (*Salix viminalis*), and its hybrids with *S. burjatica* and *S. schwerinii*, white willow *(S. alba)* and crack willow *(S. fragilis)*. Ideally a mix of willow species should be planted to impede spread of disease or pests. Planting as a monoculture may lead to improved harvesting, however inclusion as part of a mixture of tree species will improve pest and disease resistance and local biodiversity.

Willow also had roles within wastewater treatment; in Estonia, 1995, a *S, viminalis* plantation was cultivated with wastewater from a residential plot for 25 people. Results showed a significant improvement in oxygen demand and nitrogen emissions in treating water, and a first year yield of 1.6 tonnes per hectare.

For specific harvesting regimes such as short rotation coppice, Willow has a high planting density at 15,000 trees per hectare, enabling high overall yields for woodchip production to supply the biomass industry. Willow should be planted early after the last frost to enable a long first growing season without risk of exposure to sub-zero temperatures. Rods should be planted 0.75m apart with 1.5m between rows and the site should be rolled immediately after planting, with pre-emergence herbicide applied within 2-5 days of planting. Mineral soils, with a pH between 5.5 and 7.5 are recommended for planting willow plantations. Browsing animals can be a risk during establishment, but can be prevented using adequate fencing.

Shoots are generally cut back during the first winter to encourage greater shoot density the following season. The first harvest is generally taken between years 4-5 after planting, with subsequent harvests taken every three years. Yields are approximately 10-12 tonnes per hectare.

Prices for willow wood are relatively high, although prices will differ depending on quality and end use. Tree plantations may be economically improved by utilising species with improved suitability for your land type, and inclusion of a variety of tree species, rather than a singular species, may increase potential end markets *(See Short Rotation Crops)*. However, mature willow has high moisture content and lots of bark, which may make downstream processing difficult. Drying on site will increase final prices for timber and biomass, and can be achieved by letting cut billets rest for 1-2 years outside, or for 6-15 weeks in a solar kiln.

Alder

Common alder is a common timber species throughout Europe, able to adapt to a range of climates from Finland and Siberia to North Africa. It also can thrive on marginal lands, including lake shores, wet, sandy soils and rocky gravels, although it prefers moist, nutrient rich sites, and has a high tolerance to frost and salt spray. Alder is particularly sturdy in nutrient-poor soils compared to other species, due to its nitrogen fixing ability. This makes alder an important crop to consider regarding

forestry establishment on reclamation sites where soils are low in nitrogen and organic matter. It frequently grows naturally within mixtures with ash, hazel, birch and oak, and is recommended for mixtures particularly for its use as a 'nurse tree' due to its ability to fix nitrogen in soils.

Alder may be planted at very high densities (10,000-100,000 stems per hectare for short rotation coppicing or at a woodland density of 2,500 stems per hectare) although they will compete at higher densities, leading to self-thinning and slow growth. 750-1,500 stems per hectare will substantially increase diameter growth rates during the first 10-15 years. The recommended planting density is approximately 4,000 per hectare and higher, (2m between rows, 1.25m within rows), to allow for thinning of poorer quality stems during development. Due to rigorous early growth, alder should not require vegetation control at establishment, and is usually planted at 2 years old, when approximately 50-80cm tall. Early alder development is rapid, and they often grow up to a metre per year for the first 15-20 years and tend to reach full development within 30-40 years, although they don't tend to extend past 20m, with 40cm diameter. Continued thinning will favour higher quality trees and maintain diameter growth rates up to 20% higher than unmanaged stands.

Alder is mostly free from pest and disease problems, except for woodworm and *Phytophthora alni* disease – a specific alder species disease, that causes tarry deposits, poor foliage and death, generally spread from nurseries. The pathogen is also commonly carried by water, affecting riverside and streamside corridor Alder.

Alder produces a fine-grained timber, and is widely used for plywood, particularly as a veneer and may also be chipped for biomass. It also used for clog making and produces a top quality charcoal product. Alder and willow are both well-suited to water-logged soils, and are often found on land with poor drainage, creating 'wet woodland'. New woodland creation is not allowed on peat and planting schemes are rejected by NRW, as peatland is inherently better at carbon sequestration when left in its natural state.

Poplar

Poplar is a highly popular species for tree farms within the US and Europe, as one of the fastest growing trees utilisable within the climate. Rapid growth enables high yields within a few short years, and trees can grow to 5m tall by 3 years old.

Quaking aspen, cottonwood, balsam poplar and lombardy poplar are popular poplar species, and may be bred to produce rapid growing hybrids. Hybrids have the benefit of improved disease resistance, high-yields and improved timber quality, while breeding against certain limitations of their parents; for example, lombardy poplar has a poor quality timber, despite particularly high growth rates, but some of its hybrids have retained the high yields, with high quality timber production.

Hybrid poplar species can grow at approximately 6 times the growth rate of similar species, resulting in an economic return within 10-12 years. They require little maintenance compared to similar biomass crops. Poplar is ideally planted at 10,000 -20,000 trees per hectares (approximately 2m between rows, and 1m between plants within rows with harvesting gaps of 3m). For higher densities, smaller cuttings of 20-25cm, with a minimum diameter of 10mm and to include a prime bud, are advised. Poplar may be grown on marginal soils, and is often grown alongside willow and alder in mixed plantations. Weed control will be required for the first few seasons, until the canopy is mature. The plantation are harvested every 5-7 years where they're cut back to stumps to enable coppiced development with little additional planting costs.

Poplar is often used for pulp and paper industries, as a utility wood (for pallets, crates and upholstered furniture frames) and as a biomass fuel. It was a favoured timber to produce the matchstick and woodland owners planted small areas to supply timber to the match making companies such as Bryant & May. However, with the advent of the "lighter" matchstick production dwindled drastically and the poplar plantations lost their value and were left to mature and many can be seen today in areas of north east Wales.

Conifers

Over half of the UK forest land area is conifer woodlands (1.63 million hectares. Conifer wood is rapid-growing with high quality timber, and a wide range of potential uses, from building, to paper pulp, to bioenergy. Conifers are generally cold-tolerant, and wind-firm, commonly known as "evergreens" sue to their ability to withstand UK winters.

Scot's pine, yew and juniper are all native conifer species, however most conifer forestry in the UK is introduced species, including Douglas fir, Sitka spruce, Corsican pine and larch.

Conifers are generally advised to be planted at a density 2,000 – 3,000 per hectare (approx. 2m x 2m or 1.5m x 2m apart), depending on species, although, as with all plantations, a mix of species is preferential.

Scot's pine are long-lived trees, with a natural lifespan of 100-150 years and grow to approximately 36m. They are the only timber-producing conifer native to Scotland. Scot's pine are planted approximately 1.4m apart, at a density of 2,500 – 3,000 per hectare. They thrive in poor soil and support a variety of wildlife, including insects, birds and multiple mammal species, which may browse on bark, foliage and seeds. The timber is strong, albeit not naturally durable, but takes preservatives well and is commonly used for building, furniture, chipboard, telegraph poles and paper pulp. In years gone by it was planted at intervals and specific locations, for example on the brow of hills to mark and show the way for the livestock drovers along drover roads. Some of these individual trees can still be seen in the landscape today.

Douglas fir, originating from Northern America, can grow up to 100m tall, and a height of 60m is possible in British forestry. It is adapted to a range of soils, however grows best on deep, moist and well-drained clay and silt loams, and may struggle on poorly drained soils. Under suitable conditions, as Douglas fir plantation can produce up to 10-12 tonnes per hectare a year and timber is usually used for sawmill timber, paper pulp, plywood, veneers, furniture and panelling.

Sitka spruce grow to 50-60m tall, and can flourish in upland, wet or acidic soils. It is the most common tree involved with forestry in the UK, accounting for approximately 50% of all commercial plantations. A plantation of 25-40 year old Sitka should provide 350-500 tonnes per hectare with prices up to £50 a tonne. Their high-density timber is generally used for paper (smaller trees), boats, pallets and packing boxes. They are susceptible to pests such as the green spruce aphid and spruce bark beetle, and other issues such as root rot. Maelor nurseries and Tilhill forestry have produced an 'improved sitka spruce' species, with 20-30% more volume at rotation and increased yield class up to YC30.

Corsican pine are more productive than Scot's pine, with faster growth and straighter trunks, however are susceptible to red band needle blight, and are a less valuable resource to wildlife. They grow best on acidic, freely draining sandy loams, including sand dunes, and in warmer climates. They tolerate heat and drought well, but are susceptible to winter frost damage, and thus suited particularly to drier lowland areas of Britain. Corsican pine is also a light demanding pioneer species, it may not be so suited to continuous cover forestry management and requires more open conditions, particularly during early development.

A mix of conifer trees, potentially mixed with broadleaf species, is ideal, for improved resistance against pests and diseases including species specific blight, and in regards to proving a natural habitat for a richer and more diverse ecosystem.

Eucalyptus

The use of eucalyptus may be seen as controversial, as they're not a native species to the UK, and therefore may have invasion risks. However, as a fast-growing and high-quality hardwood, with significant annual yields, high pest resistance and adapted to virtually all climatic conditions, eucalyptus is a species of interest to many involved with silviculture.

From over 700 species of Eucalyptus, several have been identified as suitable for UK climates, generally sourced from Australian regions of more temperate climates, including colder winters, such as the mountains in Tasmania and parts of the great dividing range in New South Wales and Victoria. *Eucalyptus denticulata*, *E. nitens*, *E. glaucescens*, *E. gunii* and *E. globulus* are popular species for UK cultivation and *E. glaucescens* has been successfully established throughout Wales, the Midlands and Scotland, due to its adaptability to site conditions, cold tolerance and unpalatability to grazing deer.

Eucalyptus plantations of species particularly suited to the British climate, such as *E. gunnii* can produce 16-22 tonnes of dry matter per hectare, each year, making eucalyptus one of the most high yielding trees currently used in forestry in the UK.

Eucalyptus has multiple uses, not limited to timber from the wood, which may be used for wood products and bioenergy, but also the leaves provide an antiseptic oil in addition to many traditional uses utilised by indigenous populations.

Fruit orchards

Fruit producing orchards will also increase the overall benefit across the farm, particularly when planted in silvo-pastoral sites, within livestock fields. Fruit trees also confer the benefits from carbon emissions and by improving biodiversity in the surrounding habitats, although are not suitable for planting in high-yielding larger forestry situations, such as conifer or broadleaf forests. The unharvested fruit produced can feed a range of species, supporting a range of local fauna, including as complimentary fodder for livestock, with the harvested fruit proving a yearly income source.

While an extensive fruit plantation may be able to provide another commercial crop on a major scale, even a small orchard will help improve self-sufficiency on the farm and reduce the carbon footprint of the domestic grower. Planting an orchard within an Agroforestry regime can be part of a multi crop regime with the trees complementing additional crop production from the soil.

Tree Species	Broadleaf / Conifer	Planting density per hectare	Approximate yield per hectare (t/ha/year)	Other information
Willow	Broadleaf	15,000	10-12	Short rotation coppicing (SRC)
Alder	Broadleaf	10-20,000	16	Nitrogen-fixing, SRC
Poplar	Broadleaf	9,000	4-20	Yields inconsistent, SRC
Sitka Spruce	Conifer	2,500	10-20	
Douglas fir	Conifer	2,000	10-12	
Scot's Pine	Conifer	2.5 - 3,000	8-12*	*Based on 0.98m^3 per 1 tonne
Corsican Pine	Conifer	2.5 - 3,000	7-9	*Based on 0.98m^3 per 1 tonne
Eucalyptus	Broadleaf	1 - 2,000	16-22	

Conifer and broadleaf forestry

When selecting species for cultivation, suggestions should be co-ordinated to the specific site and climatic conditions, as different species will benefit most from

certain environments and soils. Consideration should also be taken with regards to the purpose of the scheme, and desired outcome of product. For timber, conifers and hardwoods should make up the majority of the plantation, while for bioenergy, only the highest yielding, rapid-growing species should be considered. If planting for carbon capture, or for fresh habitat, a range of species would be ideal, with contemplation about providing a native woodland using UK native species only. Local knowledge and Ecological Site Classification are the best methods for assessing which species a best suited to specific sites.

Ideally, a mixture of conifer and broadleaf tree species would be planted on a site, to provide maximum biodiversity, and a range of uses and resilience against pests, diseases and the duplicity of markets. ‘Nurse species’, such as nitrogen-fixing alder, are ideal companion plants in forestry plantations, and are able to support and benefit other surrounding tree species.