Tree Species Guide for UK Agroforestry Systems

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Species Guide Contents

Introduction

This tree species guide aims to provide an overview of the physical characteristics, environmental tolerances, silvicultural characteristics, and ecosystem services and disservices, for a selection of 33 species of trees and shrubs that could be planted in UK agroforestry systems.

This guide has been produced following a rapid review of existing literature and databases, together with consultation with a stakeholder group. The guide comes with some important caveats, limitations and assumptions, which are discussed in this introduction.

This guide has been developed through the Defra Nature for Climate Fund (NCF) England Tree Planting Programme (ETPP) Expanding Agroforestry project.

Who is the guide for?

The guide aims to provide a simple and accessible overview of the key attributes (whether beneficial or detrimental) of tree species in UK agroforestry systems. As such, it is suitable for farmers interested in agroforestry, and other interested parties including farm advisers, foresters, and policy makers. It is envisaged that the guide will mainly be used at an early stage in the design process, e.g., to draw up a short-list of tree species. Following this, it may be advisable for those designing an agroforestry system to seek further specialist advice appropriate to the local context.

What is agroforestry?

Agroforestry is essentially ‘farming with trees’ and includes both the integration of trees/shrubs into farmland, and the introduction of crops or livestock into treed habitats such as woodland and orchards (Raskin and Osborn, 2019). Agroforestry can be implemented at a field scale, by integrating trees/shrubs within fields as scattered trees or lines of trees, or at the landscape scale, through the productive use of hedgerows, shelterbelts and riparian buffers. Trees within agroforestry systems can have a wide range of functions and benefits, from protection of natural resources such as soil, to product diversification such as timber, woodfuel, fruits and nuts. In many cases, agroforestry systems are designed to deliver multiple, simultaneous benefits. This guide aims to inform decision-making as to tree species selection according to the identified needs in a local context.

Evidence base and sources of further information

An accompanying Excel database aims to provide transparency as to the evidential basis for the species guide. In the database, assessments are provided for each characteristic for each species, with more explanation than the pdf guide and accompanied by numbered references where appropriate. References were sourced from the UK or north-west Europe where possible. The database has been designed so that it can be updated as an ongoing process.

The following were key sources of information, which contain useful further information on tree species selection:

- The Silviculture of Trees used in British Forestry (Savill, 2019)
- The Agroforestry Handbook (Raskin and Osborn, 2019)
- The Woodland Trust's Tree Species Handbook (Hotchkiss and Herbert, 2022)
- The Essential Tree Selection Guide (Sjoman and Anderson, 2023)
- CABI Compendium (https://www.cabidigitallibrary.org/journal/cabicompendium/).

In addition, a number of freely accessible online interactive tools are available to assist with site-level decision-making for species selection. These include:

- Ecological Site Classification (http://www.forestdss.org.uk/geoforestdss/), which is used to assess suitability of forestry species for a specified site, and also contains projected distributions and productivity of some species under future climate scenarios.
- Climate matching tool (https://climatematch.org.uk/), which can inform selection of climate-resilient species.
- Ammonia reduction calculator (https://farmtreestoair.ceh.ac.uk/ammonia-reduction-calculator), used to guide the design of shelterbelts for ammonia mitigation.

How were the species selected?

The agroforestry tree species guide focusses on a priority list of 33 tree and shrub species. The species were selected through a combination of stakeholder engagement over species from the EWCO list, and consulting the list of species within the Agroforestry Handbook (Table 18, Briggs & Knight, 2019).

Species included in the guide do not necessarily represent a 'green list' of approved or recommended species and polices and regulations may differ between UK nations. Similarly, species omitted from the guide are not necessarily unsuitable for UK agroforestry systems. A notable omission is Ash *Fraxinus excelsior* which is not included due to Ash Dieback disease, but in the past has been a popular farmland tree (for example, in the UK silvopasture trial network set up in the 1980s). If constraints relating to Ash Dieback are resolved, Ash is likely to once again become worthy of consideration in agroforestry system design.

Tree Species Attributes

For each tree species, the first page of the species guide focuses on physical characteristics, tolerances, and silvicultural properties of the trees. The second page focuses on attributes (such as ecosystem services) where tree species choice is likely to influence the productivity, environmental impacts, and resilience of the agroforestry system.

The attributes were selected based on engagement with the stakeholder group. It is also recognised that agroforestry systems provide general benefits for which tree species choice is likely less relevant. One example is the extension of grazing season observed in agroforestry systems compared with treeless pastures (McAdam *et al.*, 2018), which is likely a general benefit of integrating trees within pasture where there is no clear evidence of a role of tree species choice.

The assessment of species attributes (such as ecosystem services) draws on direct evidence for species, in addition to inference based on the physical characteristics of species, such as maximum root depth, maximum height, and canopy spread. The approach to assessing attributes is discussed in the following sections, including attributes that were considered for inclusion in the guide, but ultimately could not be included due to a lack of species-specific evidence.

Colour scheme and confidence level

Attributes are colour-coded using a traffic-light system according to whether they provide a benefit or disbenefit, as follows:

Beneficial attributes (e.g. nutrient and organic matter accumulation)	**Disbenefits** (e.g. acidification)
High	High
Moderate	Moderate
Low	Low

In addition, where appropriate, for each attribute value a confidence level is displayed in the guide, as follows:

- High confidence (dark circle): direct well-replicated evidence or information from reputable sources, for the species in question.
- Moderate confidence (grey circle): evidence for the species, but less reliable, e.g. limited expert opinion or a limited number of studies / limited replication.
- Low confidence (white circle): no (or very limited) direct evidence for the species, assessment primarily inferred from other tree characteristics.

Main products

Itemised under four categories:

Tree species can contribute to the following key commercial areas:

- Food, especially fruit or nut production.
- Wood, especially high-quality timber.
- Biomass, especially for woodfuel.
- Speciality products, which are typically targeted towards a local niche market.

All tree species fulfil at least one of these categories, and in many cases more than one. The list of products focusses on those which are commonly marketed, for conciseness. However, trees often bring opportunities for numerous other speciality products, such as medicinal products, edible leaves, and dyes, depending on local market opportunities.

Fruit trees: rootstocks

Fruit trees, such as Apple, Pear, Plum and Cherry, are typically grown on rootstocks to control their vigour in addition to other benefits such as disease resistance. A summary of recommended rootstocks is provided in Table 1 below. Further guidance is readily available elsewhere[1]. Similarly, many cultivars are available for these species, both traditional and modern, offering different marketable products (e.g. dessert or culinary apples), taste, visual appearance, disease resistance, and harvesting times. Careful consideration should be given to cultivar selection in agroforestry systems to ensure suitable market opportunities and to fit in with seasonal labour demands (e.g., selecting late-ripening apple varieties to avoid conflicts with arable harvest[2]).

Table 1. Recommended rootstocks for fruit trees in agroforestry systems (adapted from information provided by Frank P Matthews).

Fruit tree	Rootstock	Size	Notes
Apple	M25	Vigorous	Vigorous planting schemes or very poor soil
	MM111	Vigorous	Vigorous planting schemes or very poor soil. Can be temperamental, generally less preferable to M25.
	MM106	Semi-vigorous	Appropriate for most schemes
	M116	Semi-vigorous	Appropriate for most schemes, similar to MM106 but with 'wet feet' resistance
Pear	Pyrus communis	Vigorous	-
	Pyrus kirchensaller	Vigorous	A more uniform rootstock from seed than P. communis
	Pyrodwarf	Semi-vigorous	Clonally produced and less suckers than P. communis or kirchensaller. The name is deceptive.

[1] E.g. https://www.frankpmatthews.com/advice/fruit_rootstocks/, https://www.rhs.org.uk/fruit/fruit-trees/rootstocks
[2] https://agroforestrynet.eu/afinet/whitehall-farm-an-innovative-silvoarable-orchard-system-in-the-uk

Fruit tree	Rootstock	Size	Notes
Pear / Quince	Quince A	Semi-vigorous	Delayed compatibility issues, only appropriate in some circumstances
Cherry	Colt	Semi-vigorous	Appropriate for most schemes
	F.12.1 / avium	Vigorous	Vigorous planting schemes or very poor soil
Plum family*	Brompton	Vigorous	Vigorous planting schemes or very poor soil. Limited supply.
	St Julien A	Semi-vigorous	Appropriate for most schemes
	Wavit / Weiwa	Semi-vigorous	Appropriate for most schemes
	Myrobalan B	Vigorous	Vigorous planting schemes or very poor soil.

* Plum family includes Plums, Damsons, Gages, Peaches, Nectarines and interspecific Prunus crosses.

Timber production

For high quality hardwood and timber in agroforestry systems it is essential to choose plants that are from an improved tree breeding programme. The system's effectiveness greatly depends on both using plants with the best genetic quality and utilising the correct provenance of the tree seedlings. Additionally, it is important to plant only healthy, high-quality saplings straight from the nursery; these are saplings that have a good ratio of shoot to root mass, are free from disease or injuries and do not have forks. For some species, hybrids or 'genetically improved' varieties are available which offer improved vigour and disease resistance.

To provide an indication of timber productivity in the species guide, maximum yield classes are stated from the Ecological Site Classification as cubic metres per ha of equivalent single-species stand, per year over a typical rotation. These are maximum values achievable under optimal site conditions and management. In reality, yields are likely to be substantially lower in almost all cases, but the values aim to allow a comparison of productivity between species. Average yield classes are also stated where known.

Impact on local soil quality

The impact of tree species on soil quality is assessed according to two sub-categories: (i) nutrient accumulation, including nutrient cycling, nitrogen fixation and other soil improving characteristics, (ii) effects on soil pH. Soil erosion control was also considered for inclusion in the guide, as described below, but is not currently included.

Nutrient and organic matter accumulation

Benefit, categorised as low, moderate, or high

Trees can help to return nutrients and organic matter to the upper soil layers by accessing nutrients at deeper soil layers than crop roots, which are subsequently released back into

the topsoil e.g. via litterfall and root breakdown (Isaac and Borden, 2019; Kim and Isaac, 2022). Although nutrient cycling is a complex topic, the most relevant traits include tree rooting depth, on the premise that deeper roots can access nutrients at greater depth, and canopy height and canopy spread which increases the distribution of leaf litter (Isaac and Borden, 2019; Casals *et al.*, 2014; Pardon *et al.*, 2017; Kassa *et al.*, 2022). As such, these three traits were primarily used to assess the nutrient accumulation potential of tree species.

The nutrient content (e.g. NPK ratio) of leaf litter, and its impact on soil nutrients, also depends on tree species (e.g. Purahong *et al.*, 2014), which is another layer of complexity beyond the remit of this rapid review.

Some trees can also increase soil nutrients through nitrogen fixation. Research of nitrogen-fixing trees is surprisingly uncommon in European agroforestry systems. One such example comprised an experimental silvopasture plot in North Wales that trialled Red Alder *Alnus rubra*, showing evidence of nitrogen fixation in the absence of fertiliser application, with equivalent pasture productivity to a Sycamore *Acer pseudoplatanus* silvopasture receiving 160 kg N/ha/year (Mmolotsi, 2004; Teklehaimanot *et al.*, 2002).

The organic matter accumulation potential of tree species is therefore broadly categorised as high, moderate, or low, based on rooting depth and canopy area, determined by tree height and canopy spread (see Table 2). Nitrogen fixation is noted separately where relevant.

Table 2. Decision matrix for predicting nutrient and organic matter accumulation of tree species.

	Small canopy area (height x width <250m^2)	Moderate canopy area (height x width <400m^2)	High canopy area (height x width >400m^2)
Deep roots	Moderate	High	High
Moderate root depth	Low	Moderate	High
Shallow roots	Low	Low	Moderate

Acidification: effects on soil pH

Disbenefit, categorised as low, moderate, or high

Tree planting on agricultural land typically increases soil acidification, i.e. decreases pH (Hagen-Thorn *et al.*, 2004; De Schrijver *et al.*, 2012; Jug *et al.*, 1999). However, this effect appears to strongly depend on tree species, because of the differing chemical composition and decomposability of leaf litter (Hagen-Thorn *et al.*, 2004). Tree species with slower litter decomposition rates and lower quantities of nutrients, such as Beech *Fagus sylvatica*, are associated with the greatest acidification effects, compared with species with rapidly decomposing litter such as Lime *Tilia* spp., in forest plantations on former agricultural land (Hagen-Thorn *et al.*, 2004; De Schrijver *et al.*, 2012).

A rapid evidence review has been undertaken to assess the effect of tree species on soil pH, albeit these are largely from forestry contexts. Tree species are classified as having high, moderate or low impacts, with ‘high’ species having the greatest effect on soil

acidification (decrease in pH). Species categorised as 'low' would typically still have an acidifying effect, but less pronounced than in 'high' species. The categorisation was undertaken by benchmarking against relatively well-studied species included in multiple studies (see Table 3). Some species are categorised as 'unknown' where it was not possible to benchmark their acidification effect against other species, but in some of these species there is still evidence for an acidification effect after planting.

Table 3. Overview of acidification effects of relatively well studied tree species following the rapid literature review (see accompanying database for references).

Species	Acidification effect	Comments
Fagus sylvatica	High	Typically associated with highest acidification effects of broadleaved species
Quercus robur	High	Similar, or slightly less, acidification effects as *F. sylvatica*
Alnus glutinosa	High	Typically similar effects to native *Quercus*
Acer pseudoplatanus	Moderate	Intermediate between *Quercus* and *Tilia*
Tilia spp.	Low	Typically lowest acidification effects of broadleaved species

Soil erosion control

Not included in the guide

Control of soil erosion is often cited as one of the primary benefits of planting trees on agricultural land (Sollen-Norrlin *et al.*, 2020; Torralba *et al.*, 2016). Soil erosion can occur through water or wind. Erosion from wind can be controlled by planting an effective windbreak, which depends more on planting density and tree height than on species choice *per se* (Böhm *et al.*, 2014).

Research on the effectiveness of different tree species to control soil erosion by water is very limited. Willow *Salix* spp. and Poplar *Populus* spp. species are commonly recommended because of their rapid growth, extensive lateral root systems, and tolerance of wet soil conditions (Stokes *et al.*, 2014). Their extensive root systems are also likely to help stabilise soils. Trees with deep root systems as well as an extensive root mass are likely to be most effective at stabilising soil (Ola *et al.*, 2015; Reubens *et al.*, 2007), while leaf litter production also helps to protect soil (Castro-Díez *et al.*, 2019). However, the situation is complicated by the possibility of soil type interacting with root architecture to determine the benefit of trees on controlling soil erosion (Vannoppen *et al.*, 2017).

Although careful consideration was given to the inclusion of this attribute in the guide, especially given the significant benefits of agroforestry systems on soil erosion control (Torralba *et al.*, 2016), at this stage soil erosion control has not been included in the guide due to a lack of evidence as to the importance of root architecture, tree growth rates, and their interaction with soil types. Further research of the effects of tree root architecture on soil erosion in different soil types is therefore needed (Stokes *et al.*, 2014).

Shade cover impacts

Benefit or disbenefit depending on system; categorised under three subcategories

Tree shade can be a desirable property in terms of livestock welfare and growth, or an undesirable property in most arable or horticultural systems in the UK. The effect of trees on spatial and temporal shading patterns is complex and depends on planting arrangement (particularly in an alley cropping system) and tree management. In the species guide, the impact of shade is reported using the following three sub-categories:

- **Size of shadow**, categorised as 'low', 'moderate' or 'high'. This is determined by the canopy volume, estimated from the maximum tree height, width, and canopy shape. Based on these variables, the area of the shadow cast by the tree is estimated, and then categorised by benchmarking against the wider species list.
- **Canopy density**, categorised as open, moderately open, moderately dense, or dense.
- **Leaf emergence**, categorised as 'early' (in April), 'late' (in May), or evergreen.

Livestock fodder benefits

Benefit, categorised as low, moderate, high, or (potentially) toxic

This category assesses the potential of each species to be used as supplementary fodder for livestock. The value of tree fodder for livestock varies according to site, season, and the part of the plant, in addition to tree and livestock species. Some nutrients, such as zinc and cobalt, strongly vary among different tree species, while others (such as selenium) appear to be more dependent on site conditions with only minor differences between species (Kendall *et al.*, 2021).

Given the importance of variables such as site and season, which vary between studies, this assessment does not include numeric values for the concentration of nutrients per species, but instead reports any nutrients or minerals shown to be present at high concentrations relative to other tree species and pasture forage. Potential disbenefits from low concentrations of particular nutrients or minerals in a species are not reported, on the assumption that any individual tree species will only be a minor supplementary component of the diet, such that any shortfalls are unlikely to be problematic in the context of a wider balanced diet. However, negative aspects are stated where the literature indicates a species has palatability or toxicity concerns.

A broad assessment of the species' benefit to livestock is evaluated as high, moderate, or low, based on evidence of nutritional value, including crude protein, condensed tannins, micronutrient levels, and palatability. For example, Italian Alder *Alnus cordata* is categorised as 'moderate' value because of its high crude protein and condensed tannin content, balanced against its low palatability. Where there is significant risk of toxicity (e.g. Wild Cherry *Prunus avium* and Bird Cherry *P. padus*), this is stated instead of the high-low nutritional value. Otherwise, a more specific or limited risk of toxicity is added as a note

following the assessment of nutritional value (e.g. for Sessile Oak *Quercus petraea,* where there is some toxicity risk in certain plant parts / livestock types).

Risks to farming operations

Free text

This is a broad category which includes any other risks to productivity and farming operations that were encountered during the review. Particular attention was given to any tendency to readily spread, for example through suckering roots or prolific production of seeds that easily germinate. Other risks include allelopathy (toxicity to other plant species), risks to agricultural production other than pests and diseases, secondary hosts for pests of agricultural crops, and flammability.

Carbon sequestration

Benefit, categorised as very low, relatively low, moderate, high, or very high

Carbon sequestration in agroforestry systems is a complex topic which depends on a range of variables such as planting density, tree management, vigour of tree growth, and site characteristics including climate (Soil Association, 2023). As such, the approach taken in this guide is to provide the maximum likely achievable carbon sequestration for each tree species using the Woodland Carbon Code[3], assuming that trees are planted at 3m spacing (2m for Scots Pine). A maximum possible yield class for the UK (according to the Ecological Site Classification) was assumed for each species, to provide a consistent and comparable approach accounting for differences in productivity by species. For small non-timber species such as Apple *Malus domestica*, carbon sequestration was assumed to be 'relatively low' in the short-term, and 'very low' in the medium- and long-term.

Soil carbon sequestration was not considered in the assessment, because of the lack of species-specific evidence from agroforestry systems. Other factors such as agricultural management practices, previous land use, and soil type are likely to be more relevant. However, evidence from forestry planting indicates that deciduous broadleaved species sequester significantly more soil carbon than coniferous species, with broadleaved nitrogen-fixing species having the strongest effect (Laganière *et al.*, 2010).

The carbon sequestration values provided in the database represent tonnes of CO_2 equivalent within 1 ha of trees. As such, these figures should be multiplied by tree percentage in an agroforestry system, e.g., multiply by 0.1 for an agroforestry system comprising 10% trees for an approximate estimation. However, the values provided are not intended to be a realistic assessment of carbon sequestration in agroforestry systems (given that maximum yield classes were selected), but rather provide a comparable benchmark with which to make comparisons between species.

Three timeframes for carbon sequestration are presented in the guide: short-term (20 years), medium-term (40 years), and long-term (60 years). These refer to time after tree

[3] https://woodlandcarboncode.org.uk/

planting, assuming no coppicing, pollarding, thinning, or felling. As such, the medium-term and long-term categories are not applicable for trees managed on a coppice rotation of less than 20 years.

For each of the three timeframes, carbon sequestration is categorised by benchmarking the sequestration values described above against the wider tree species list. This means that, for example, Field Maple *Acer campestre* delivers very low carbon sequestration relative to other tree species in the guide, but could still increase carbon sequestration relative to a non-tree scenario.

Native status

Categorised as native, long-established introduction, or recent introduction

Native status is adapted from Stace's New Flora (2019), based on the following categories and sub-categories:

- Native: a species that colonised the British Isles naturally, typically long ago, from other native areas.
- Long-established (archaeophyte): a species typically associated with human activities or suspected to be introduced by humans, and present in the British Isles since at least 1500 AD. It is often uncertain whether the species is native or introduced. Further divided into the following sub-categories:
    - Denizen: behaves like a native species but suspected to be a possible human introduction (either intentionally or accidently).
    - Cultivated: introduced by humans as crops, now persisting in the wild.
- Recent introduction (neophyte): a non-native species that arrived in the British Isles after 1500 AD, sub-categorised as:
    - Naturalised: established in the wild and not reliant on replanting.
    - Survivor: not naturalised, but persists without spreading, usually a relic of planting.

Native status sometimes varies across the UK, and in these cases, the 'highest' status is given (e.g., a species which is native to part of the UK but introduced elsewhere is categorised as 'native' for simplicity).

Value to wildlife

Benefit, categorised as relatively negligible, low, moderate, high, or very high

The value of tree species for native wildlife is derived from an article published in British Wildlife (Alexander *et al.*, 2006). In the article, the authors estimate the value of tree species for nine different categories of species assemblages, such as 'mycorrhizal fungi', 'foliage invertebrates', 'blossom for pollen and nectar' and 'epiphyte communities', using a scoring system of 1 to 5. The values were estimated based on the opinions of a selection of established and published experts. A number of assumptions were made, including that the trees are maidens (i.e., no coppicing or pollarding) with no constraints associated with commercial operations such as inputs or other ecologically harmful management.

In the species guide, the values in the article are summarised by firstly providing an overall value of the tree species for wildlife by averaging the values (1-5) across all nine assemblage categories, which are then categorised as relatively low (average value <2.5), moderate (average value >2.5 and ≤3), and high (average value >3), with a very high category used for native *Quercus* because these were substantially higher than any other species. Secondly, the assemblage(s) for which the tree species had the highest score is stated.

For species not included in the above article, their value is inferred based on their native status and similarity to species that are included in the article. For example, Italian Alder *Alnus cordata* is predicted to have low to moderate wildlife value, based on the 'moderate' score for Common Alder *A. glutinosa*, but accounting for the introduced status of Italian versus the native Common Alder.

As for the carbon values, it should be noted that tree species' value to wildlife scores are benchmarked against the wider tree species list, not relative to non-tree scenarios. For example, planting a tree species of 'relatively low' biodiversity value in an otherwise monoculture of arable or pasture could lead to substantial and significant biodiversity benefits. The extent of these benefits are likely to depend on a range of variables including management of the tree and its understorey vegetation, tree density, habitat connectivity, and management of the adjacent crop/pasture (reviewed in Kletty *et al.*, 2023).

Other environmental impacts

Free text, limited number of tree species covered

This section includes wider environmental impacts which were considered for inclusion as separate categories in the guide, but for which limited species-specific evidence is available, as described below.

Nutrient removal and deacidification

Trees can play an important role in mitigating nutrient leaching and acidification into nearby habitats, including watercourses and terrestrial plant communities adapted to low nutrient conditions. However, tree species selection is likely to play a relatively minor role, compared with hydrogeological properties including soil type and depth and water table height (Hill, 2019), in addition to tree management (T. Nisbet pers. comm.). Indeed, a meta-analysis found no significant difference in nutrient uptake among buffer strips comprising different vegetation types, including trees versus herbaceous buffers (Mayer *et al.*, 2007).

Nevertheless, some evidence suggests that Poplars and Willows are particularly efficient at removing nitrate from water (Nisbet *et al.*, 2011; Regni *et al.*, 2021), while Poplar is also particularly effective at removing atmospheric ammonia (Tang *et al.*, 2022; CEH, n.d.). These species are also able to increase nitrate uptake when present at higher concentrations (Regni *et al.*, 2021). To at least some extent, this is likely due to the rapid

growth of these species and will therefore be strongly influenced by tree management (T. Nisbet pers. comm.).

It has also been hypothesised that root architecture plays a role in nutrient accumulation, with deeper-rooting species such as Walnut *Juglans* spp. potentially more effective at reducing nitrogen leaching because of a greater 'safety net' effect (Andrianarisoa *et al.*, 2016). This hypothesis warrants further research, but there is insufficient evidence at present to include in the guide.

In some cases, trees can worsen leaching of nutrients into watercourses, and contribute to surface water acidification (Nisbet and Evans, 2014). This includes nitrogen-fixing Alder *Alnus* species, where nitrogen levels are already high, and species which consume high quantities of water coupled with limited nutrient uptake, such as Scots Pine *Pinus sylvestris*.

In terms of atmospheric nutrient removal, an online ammonia reduction tool provides advice on the design of shelterbelts for ammonia mitigation, including species selection (CEH, n.d.). Although the effect of species on ammonia recapture depends on location and soil type, Aspen *Populus tremula* is generally the best-performing species of those included in the tool. However, other factors such as buffer dimensions are more important than species selection.

Given the apparently limited role of species selection for nutrient removal and deacidification, except in some cases, no specific category is included in the species guide, and key species (whether beneficial or detrimental) such as Alder, Poplars and Willows are referred to within the 'other environmental impacts' category.

Water consumption

High water use by trees can either be beneficial in areas of excess water, such as those which are prone to flooding, or detrimental where water is in short supply and there is a risk of drought. Generally, trees typically use more water than herbaceous vegetation such as pasture or arable crops. Comparable species-specific information on water use is scarce, and plays a secondary role to climatic and soil factors, in addition to tree management (given that growing trees generally use more water than mature trees) (Nisbet, 2005; T. Nisbet pers. comm.). Therefore, water consumption by species is not included as a separate category in this guide.

Broadly speaking however, evergreen coniferous species have higher water consumption than broadleaved species, and of the broadleaved species, high-growth trees managed on a short rotation coppice have the highest consumption (Nisbet, 2005; T. Nisbet pers. comm.). In particular, Willow and Poplar have very high transpiration rates in wet soil conditions (Nisbet, 2005), but less so in drier soils (Hall *et al.*, 1996; T. Nisbet pers. comm.). Similarly, there is evidence of high water use of Common Alder *Alnus glutinosa* when soil water content is high (Herbst *et al.*, 1999). As such, the potential for high water consumption is noted for these species under 'other environmental impacts'.

Spray-drift reduction

Not included in the guide

Trees can also help to reduce spray-drift of agrochemicals onto nearby habitats. Traits such as timing of leaf emergence (Wenneker and Van de Zande, 2008) and leaf structure, hairiness and coarseness (Ucar and Hall, 2001; Ucar *et al.*, 2003; Bentrup *et al.*, 2019) appear to be important in determining the effect of a species, although other characteristics such as the height, width and porosity of a tree row or hedgerow are possibly more important (reviewed in Bentrup *et al.*, 2019; Ucar and Hall, 2001). As such, given the limited evidence at present, this category is not included in the guide.

Susceptibility to pests and disease

Disbenefit, categorised under three subcategories as low, moderate, or high

Three categories are assessed, namely susceptibility to (i) disease, (ii) invertebrate pests (e.g. insects), and (iii) vertebrate pests (e.g. mammals and birds).

For each category, a broad classification is made as follows:

- High susceptibility: the species is commonly affected by a pest or disease which causes serious damage (e.g., major loss of crop or tree mortality).
- Moderate susceptibility: the species is commonly affected by a pest or disease which causes less serious damage, i.e. trees can often make a full recovery, or less commonly affected by a serious pest/disease.
- Low susceptibility: major pest or disease issues are rare.

The above categories are generalised for the UK at the time of writing. In reality, pest and disease issues are complex and depend on numerous factors such as climate, the presence of the pest or disease in the local area either currently or in the recent past, the composition of habitats and plant species locally and in the wider landscape, and tree stress (e.g., caused by unfavourable environmental conditions). In addition, populations of tree pests and diseases are rapidly changing and there is a constant threat of new pests and diseases colonising the UK, primarily due to climate change and global trade. It is advisable that a mixture of species, or at least varieties, are planted in agroforestry systems to help mitigate this threat.

Climate resilience

Benefit, categorised as low, moderate or high

The resilience of each tree species to projected climate change was assessed by undertaking a rapid review of the literature for each species, e.g. using the search terms “Juglans regia climate change UK”, in addition to reviewing grey literature. The identified studies typically assess climate resilience by modelling species’ environmental tolerances such as temperature requirements and drought tolerance against projected 2050 climate change scenarios, and do not typically account for any changes in community dynamics, for example from pest pressure or competition from other tree species. Where

species-specific evidence was not found in the literature, a prediction is made based on the environmental tolerances of the species and its native distribution. The resilience of each species is evaluated according to three categories based on the available evidence:

- High: UK climate likely to generally become more suitable for the species, which is projected to expand its range within the UK with very limited areas of reduced suitability.
- Moderate: mixed effects of projected climate change in the UK, e.g. projected expansion in the north, but with reduced suitability in a comparable area in the south.
- Low: projected climate change likely to result in substantially reduced suitability for the species in the UK, with limited range expansion.

For example, Sycamore *Acer pseudoplatanus* is categorised as ‘moderate’ because the species is likely to become less suited to the south-east, east and midlands of England, but more suited to northern England and south-east Scotland, such that its overall range would cover a similar area.

Note that each species is broadly assessed across the UK. In reality, the effect of climate change on species’ suitability is often strongly dependent on the region of the UK.

Tree Species List

Common Name	Latin Name
Field Maple	*Acer campestre*
Sycamore	*Acer pseudoplatanus*
Italian Alder	*Alnus cordata*
Common Alder	*Alnus glutinosa*
Red Alder	*Alnus rubra*
Paper-bark Birch	*Betula papyrifera*
Silver Birch	*Betula pendula*
Downy Birch	*Betula pubescens*
Hornbeam	*Carpinus betulus*
Sweet Chestnut	*Castanea sativa*
Hazel	*Corylus avellana*
Cider Gum	*Eucalyptus gunnii*
Beech	*Fagus sylvatica*
Black Walnut	*Juglans nigra*
Walnut	*Juglans regia*
Apple	*Malus domestica* / cultivars
Scots Pine	*Pinus sylvestris*
Black-poplar	*Populus nigra* ssp*. betulifolia*
Hybrid poplars (timber)	*Populus* spp.
Aspen	*Populus tremula*
Wild Cherry	*Prunus avium*
Plum	*Prunus domestica* ssp*. domestica*
Bird Cherry	*Prunus padus*
Pear	*Pyrus communis*
Sessile Oak	*Quercus petraea*
Pedunculate Oak	*Quercus robur*
Red Oak	*Quercus rubra*
White Willow	*Salix alba*
Goat Willow	*Salix caprea*
Grey Willow	*Salix cinerea*
Willow varieties (SRC)	*Salix* spp.
Rowan	*Sorbus aucuparia*
Small-leaved Lime	*Tilia cordata*

Species Guide

Field Maple (*Acer campestre*)

Physical	
Typical systems	Arable Pasture Lowland
Max. height	Typically up to **15m**, exceptionally 25m
Canopy cover	Rounded 4-8m wide
Canopy density	Dense
Root architecture	Very shallow
Growth rate	Moderate to high
Silviculture	
Establishment time	**10-20 years** to maximum height
Establishment requirements	Protection from browsing
Management requirements	Minimal to no pruning
Longevity	Usually up to **120 years**, potentially 200+ years
Rotation length	Typically **8-15 years**, up to 30 years
Approach to silviculture	Coppices well
Tolerances	
High temperatures	Tolerant
Low temperatures	Hardy
Wind	Tolerant
Drought	Moderately tolerant
Waterlogging	Moderately sensitive to sensitive
Soil types	Neutral to calcareous, moist but well-drained
Slope and aspect	Any
Shade tolerance	Full sun or partial shade

Productivity		
Main products	Food	-
	Wood	Timber, low yielding
	Biomass	Woodfuel
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Low ❍
	Acidification	Moderate ❍
Shade cover impacts*	Size of shadow (full-grown)	Moderate ●
	Canopy density	Dense ●
	Leaf emergence	Early ●
Livestock fodder benefits		Low to moderate (low crude protein, moderate nutritional value) ●
Risks to farming operations		Could inhibit growth of nearby plants
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Very low
	Long-term (60 yrs)	Very low
Native status		Native ●
Value to wildlife		Relatively low, highest value for pollen & nectar ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	Low to moderate ●
	Invertebrates	Moderate ●
	Vertebrates	High, especially Rabbits ●
Climate resilience		High ●

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Sycamore (*Acer pseudoplatanus*)

Physical	
Typical systems	Arable Pasture Lowland and upland
Max. height	Typically up to **35m**, exceptionally 40m
Canopy cover	Broad, domed to ovoid >8m wide
Canopy density	Moderate when young, otherwise dense
Root architecture	Shallow to moderate, extensive
Growth rate	Moderate to high
Silviculture	
Establishment time	**>50 years** to maximum height
Establishment requirements	Protection from browsing Benefits from weed control
Management requirements	Minimal to no pruning, self-prunes well
Longevity	**400 or 500** years
Rotation length	Typically **65-75 year** timber rotation, up to 100 years
Approach to silviculture	Can be coppiced up to 80-100 years Can be pollarded
Tolerances	
High temperatures	Moderately sensitive
Low temperatures	Very hardy
Wind	Tolerant, but benefits from shelter
Drought	Moderately sensitive
Waterlogging	Moderately sensitive to sensitive
Soil types	Wide range, preferring deep well-drained soils
Slope and aspect	Any
Shade tolerance	Full sun or partial shade

Productivity		
Main products	Food	-
	Wood	Timber, moderately high yielding
	Biomass	Woodfuel
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Moderate ❍
	Acidification	Moderate ●
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Dense ●
	Leaf emergence	Late ●
Livestock fodder benefits		Low to moderate (conflicting evidence for crude protein, low digestibility) ● Risk of toxicity in horses
Risks to farming operations		Self-sows freely, potential weed
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	High
	Medium-term (40 yrs)	High
	Long-term (60 yrs)	High
Native status		Recent introduction (Neophyte – naturalised) ●
Value to wildlife		High, especially foliage invertebrates, leaf litter, epiphytes ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	Moderate to high ●
	Invertebrates	Moderate ●
	Vertebrates	High (especially squirrels) ●
Climate resilience		Moderate ●

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Italian Alder (*Alnus cordata*)

Physical	
Typical systems	Arable Lowland
Max. height	**20 to 29m**
Canopy cover	Conical 4-8m wide
Canopy density	Moderately dense
Root architecture	Shallow
Growth rate	High
Silviculture	
Establishment time	**20 to 50 years** to maximum height
Establishment requirements	Minimal
Management requirements	Minimal to no pruning
Longevity	**60 to 100** years
Rotation length	At least **20-30 year** timber rotation
Approach to silviculture	Variable coppicing ability, rotation 15-30 years
Tolerances	
High temperatures	Moderately tolerant
Low temperatures	Hardy
Wind	Tolerant
Drought	Tolerant, but reduces growth in drought
Waterlogging	Moderately tolerant
Soil types	Prefers deep chalky soils
Slope and aspect	Any
Shade tolerance	Full sun or partial shade

Productivity		
Main products	Food	-
	Wood	Timber, pulpwood, moderately high yielding
	Biomass	Firewood
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Nitrogen fixing ● Otherwise low ❍
	Acidification	High ❍
Shade cover impacts*	Size of shadow (full-grown)	Low ●
	Canopy density	Moderately dense ●
	Leaf emergence	Late ●
Livestock fodder benefits		Moderate (high protein content, low palatability) ●
Risks to farming operations		None known
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	High
	Medium-term (40 yrs)	High
	Long-term (60 yrs)	High
Native status		Recent introduction (Neophyte – naturalised) ●
Value to wildlife		Low to moderate ❍
Other environmental impacts		Risk of increased nitrate leaching and acidification
Resilience		
Pest/disease susceptibility	Diseases	Moderate ●
	Invertebrates	Low ●
	Vertebrates	Low ❍
Climate resilience		High ❍

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Common Alder (*Alnus glutinosa*)

Physical	
Typical systems	Arable Pasture Lowland to semi-upland
Max. height	Typically **12 to 25m**, exceptionally 40m
Canopy cover	Broad, conical to ovoid 4-10m wide
Canopy density	Open
Root architecture	Moderate, to very shallow in wet soils
Growth rate	Moderate to high
Silviculture	
Establishment time	**20 to 50 years** to maximum height
Establishment requirements	Minimal
Management requirements	Minimal to no pruning
Longevity	Typically **100** years, potentially >250 years, only 20-25 years on poor sites
Rotation length	Maximum rotation **60-70 years**
Approach to silviculture	Coppices well when young Can be pollarded
Tolerances	
High temperatures	Moderately tolerant
Low temperatures	Very hardy
Wind	Tolerant, but shelter required for straight stems
Drought	Moderately sensitive to sensitive, especially when young
Waterlogging	Tolerant
Soil types	Requires moist soils, otherwise undemanding
Slope and aspect	Any
Shade tolerance	Full sun or partial shade

Productivity		
Main products	Food	-
	Wood	Low quality timber, moderately high yielding
	Biomass	Biomass, charcoal
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Nitrogen fixing ● Otherwise low ❍
	Acidification	High ●
Shade cover impacts*	Size of shadow (full-grown)	Moderate ●
	Canopy density	Open ●
	Leaf emergence	Early ●
Livestock fodder benefits		Moderate (high crude protein, moderate digestibility, low palatability) ●
Risks to farming operations		Potential weed, readily self-sows
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	High
	Medium-term (40 yrs)	High
	Long-term (60 yrs)	High
Native status		Native ●
Value to wildlife		Moderate, highest value for foliage invertebrates, fruits & seeds ●
Other environmental impacts		Risk of increased nitrate leaching and acidification High water consumption in wet conditions
Resilience		
Pest/disease susceptibility	Diseases	Moderate ●
	Invertebrates	Low ●
	Vertebrates	Low to moderate ●
Climate resilience		Moderate ●

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Red Alder (*Alnus rubra*)

Physical	
Typical systems	Pasture Lowland
Max. height	Typically to **15m**, exceptionally 25m
Canopy cover	Narrow, pyramidal 4-8m wide
Canopy density	Moderately open
Root architecture	Moderate, extensive
Growth rate	High
Silviculture	
Establishment time	**20 to 50 years** to maximum height
Establishment requirements	Minimal
Management requirements	Minimal to no pruning
Longevity	Up to 60-100 years, but typically begins to die back after 15 years
Rotation length	Pulpwood 10-12 years, sawlog 30-32 years
Approach to silviculture	Coppices well on short cycles when young
Tolerances	
High temperatures	Sensitive
Low temperatures	Very hardy, but susceptible to spring frosts
Wind	Tolerant
Drought	Tolerant when established
Waterlogging	Unknown
Soil types	Moist but well-drained
Slope and aspect	Avoid north-facing
Shade tolerance	Full sun

Productivity		
Main products	Food	-
	Wood	Timber and pulpwood, moderately high yielding
	Biomass	-
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Nitrogen fixing ● Otherwise low ❍
	Acidification	High ❍
Shade cover impacts*	Size of shadow (full-grown)	Low ●
	Canopy density	Moderately open ●
	Leaf emergence	Early ●
Livestock fodder benefits		Poorly understood, likely low palatability ❍
Risks to farming operations		Poor growth in most UK trials
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	High
	Medium-term (40 yrs)	High
	Long-term (60 yrs)	High
Native status		Recent introduction (Neophyte – naturalised) ●
Value to wildlife		Low to moderate ❍
Other environmental impacts		Risk of increased nitrate leaching and acidification
Resilience		
Pest/disease susceptibility	Diseases	Moderate ●
	Invertebrates	Low ●
	Vertebrates	Low ❍
Climate resilience		High ❍

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Paper-bark Birch (*Betula papyrifera*)

Physical	
Typical systems	Lowland
Max. height	Typically to **23-25m**, exceptionally 30m
Canopy cover	Ovoid, spreading >8m wide
Canopy density	Open
Root architecture	Shallow
Growth rate	High
Silviculture	
Establishment time	**20 to 50 years** to maximum height
Establishment requirements	Regular mulching / weed control
Management requirements	Minimal to no pruning
Longevity	Up to **200 years**
Rotation length	Likely **30-40 year** timber rotation
Approach to silviculture	Coppices weakly Pollards weakly
Tolerances	
High temperatures	Sensitive
Low temperatures	Very hardy
Wind	Tolerant
Drought	Sensitive
Waterlogging	Sensitive
Soil types	Wide range, favours deep, fertile and well aerated soils
Slope and aspect	Any
Shade tolerance	Full sun to partial shade

Productivity		
Main products	Food	-
	Wood	Pulpwood
	Biomass	-
	Speciality	Tree sap
Impact on local soil quality	Nutrient and organic matter accumulation	Low ❍
	Acidification	Conflicting evidence
Shade cover impacts*	Size of shadow (full-grown)	Moderate ●
	Canopy density	Open ●
	Leaf emergence	Early ●
Livestock fodder benefits		Poorly understood ❍
Risks to farming operations		Highly flammable bark
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Moderate
	Medium-term (40 yrs)	Moderate
	Long-term (60 yrs)	Relatively low
Native status		Recent introduction (Neophyte – survivor) ●
Value to wildlife		Moderate to high ❍
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Low (high future risk) ●
	Vertebrates	Low to moderate ❍
Climate resilience		High ❍

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Silver Birch (*Betula pendula*)

Physical	
Typical systems	Pasture Arable Lowland to semi-upland
Max. height	Typically to **15-20m**, exceptionally 30m
Canopy cover	Columnar, tapering 4-8+m wide
Canopy density	Open
Root architecture	Shallow, deeper on dry sites
Growth rate	High
Silviculture	
Establishment time	**20 to 50 years** to maximum height
Establishment requirements	Regular mulching / weed control Protection from browsing
Management requirements	Minimal to no pruning
Longevity	Typically up to **100 years**, exceptionally 200 years
Rotation length	**30-40 year** timber rotation
Approach to silviculture	Coppices weakly
Tolerances	
High temperatures	Sensitive
Low temperatures	Very hardy
Wind	Tolerant
Drought	Sensitive
Waterlogging	Sensitive
Soil types	Favours light, well-drained, acid soils
Slope and aspect	Any
Shade tolerance	Full sun to partial shade

Productivity		
Main products	Food	-
	Wood	Usually pulpwood, moderate to low yielding
	Biomass	-
	Speciality	Tree sap
Impact on local soil quality	Nutrient and organic matter accumulation	Generally low ❍ Useful for restoration of acid soils ●
	Acidification	Conflicting evidence
Shade cover impacts*	Size of shadow (full-grown)	Moderate ●
	Canopy density	Open ●
	Leaf emergence	Early ●
Livestock fodder benefits		Low to moderate ❍
Risks to farming operations		None known
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	High
	Medium-term (40 yrs)	High
	Long-term (60 yrs)	High
Native status		Native ●
Value to wildlife		High, especially mycorrhizal fungi and foliage invertebrates ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Low (high future risk) ●
	Vertebrates	Low to moderate ●
Climate resilience		Moderate ●

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Downy Birch (*Betula pubescens*)

Physical	
Typical systems	Pasture Lowland and upland
Max. height	Typically up to **20m**, exceptionally 30m
Canopy cover	Irregular 6-8m wide
Canopy density	Open
Root architecture	Shallow to moderate
Growth rate	Moderate to high
Silviculture	
Establishment time	**20 to 50 years** to maximum height
Establishment requirements	Regular mulching / weed control Protection from browsing
Management requirements	Minimal to no pruning
Longevity	Typically up to **100 years**, exceptionally 200 years
Rotation length	**30-40 year** timber rotation
Approach to silviculture	Coppices weakly, long rotation
Tolerances	
High temperatures	Sensitive
Low temperatures	Very hardy
Wind	Tolerant
Drought	Sensitive
Waterlogging	Moderately tolerant
Soil types	Wide range, favours more acid, wet, peaty soils
Slope and aspect	Any
Shade tolerance	Full sun to partial shade

Productivity		
Main products	Food	-
	Wood	Timber and pulpwood, relatively low yielding
	Biomass	Woodfuel
	Speciality	Tree sap
Impact on local soil quality	Nutrient and organic matter accumulation	Generally low ❍ Useful for restoration of acid soils ●
	Acidification	Conflicting evidence
Shade cover impacts*	Size of shadow (full-grown)	Low ●
	Canopy density	Open ●
	Leaf emergence	Early ●
Livestock fodder benefits		Low to moderate ❍
Risks to farming operations		None known
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Moderate
	Medium-term (40 yrs)	Moderate
	Long-term (60 yrs)	Relatively low
Native status		Native ●
Value to wildlife		High, especially mycorrhizal fungi and foliage invertebrates ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Low (high future risk) ●
	Vertebrates	Low to moderate ●
Climate resilience		Low ●

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Hornbeam (*Carpinus betulus*)

Physical	
Typical systems	Arable Pasture Lowland
Max. height	Typically up to **25m**, exceptionally 32m
Canopy cover	Ovoid to globular >8m wide
Canopy density	Dense
Root architecture	Shallow to moderate
Growth rate	Low to moderate
Silviculture	
Establishment time	**>50 years** to maximum height
Establishment requirements	Protection from squirrel damage
Management requirements	Minimal to no pruning
Longevity	Potentially **400+ years**
Rotation length	**15-25 year** to **30-40 year** coppice rotation
Approach to silviculture	Coppices well Can be pollarded
Tolerances	
High temperatures	Tolerant
Low temperatures	Very hardy
Wind	Tolerant
Drought	Moderately tolerant
Waterlogging	Sensitive
Soil types	Wide range, favours moderately fertile, damp soils
Slope and aspect	Any
Shade tolerance	Full sun to at least partial shade

Productivity		
Main products	Food	-
	Wood	Specialised timber, moderate yielding
	Biomass	Woodfuel, charcoal
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Low to moderate ❍
	Acidification	High ●
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Dense ●
	Leaf emergence	Early ●
Livestock fodder benefits		Low (moderate crude protein, low nutritional value) ●
Risks to farming operations		None known
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Moderate
	Long-term (60 yrs)	Moderate
Native status		Native ●
Value to wildlife		Relatively low, highest value for mycorrhizal fungi, leaf litter, seeds ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Low ●
	Vertebrates	Moderate to high (especially squirrels) ●
Climate resilience		High ●

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Sweet Chestnut (*Castanea sativa*)

Physical			
Typical systems	Arable	Pasture	Lowland to semi-upland
Max. height	**30 to 35m**		
Canopy cover	Ovoid to irregular		>8m wide
Canopy density	Dense		
Root architecture	Moderate to deep, extensive		
Growth rate	Moderate to high		
Silviculture			
Establishment time	**20-50 years** to maximum height, full nut production in 10-15 years		
Establishment requirements	Minimal		
Management requirements	Minimal to no pruning		
Longevity	Potentially **300-1000 years**		
Rotation length	**12-16 years** coppice, **25-30 years** pulpwood		
Approach to silviculture	Coppices well		
Tolerances			
High temperatures	Tolerant		
Low temperatures	Hardy (but cultivars can be sensitive to frost)		
Wind	Potentially sensitive		
Drought	Moderately sensitive to tolerant (cultivars typically more sensitive)		
Waterlogging	Sensitive		
Soil types	Wide range, favours acid to neutral, moist but well-drained soils		
Slope and aspect	Any		
Shade tolerance	Full sun to partial shade		

Productivity		
Main products	Food	Nuts, typically using hybrid cultivars
	Wood	Timber, pulpwood, poles, moderately high yielding
	Biomass	Woodfuel (low quality)
	Speciality	Tannins for leather etc., mushroom cultivation
Impact on local soil quality	Nutrient and organic matter accumulation	High ❍ Useful soil improver on light soils ●
	Acidification	Unknown
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Dense ●
	Leaf emergence	Late ●
Livestock fodder benefits		Conflicting evidence. Nuts used for pig feed.
Risks to farming operations		Timber often affected by ring shake
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Moderate
	Long-term (60 yrs)	Moderate
Native status		Long-established (Archaeophyte – cultivated) ●
Value to wildlife		Relatively low, highest value for seeds ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Low ●
	Vertebrates	Moderate ●
Climate resilience		Moderate to high ●

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Hazel (*Corylus avellana*)

Physical	
Typical systems	Arable Pasture Lowland
Max. height	Typically up to **6m**, potentially 10m
Canopy cover	Globular, spreading 4-8m wide
Canopy density	Moderately dense
Root architecture	Shallow, limited extent
Growth rate	Moderate
Silviculture	
Establishment time	**5-10 years** to maximum height, full nut production from c. 10 years
Establishment requirements	Protection from browsing
Management requirements	Minimal to no pruning
Longevity	Typically **70-80 years**, potentially 200+ years
Rotation length	**6-9 years** coppice, or 14-16 years with standard trees
Approach to silviculture	Coppices well
Tolerances	
High temperatures	Moderately tolerant
Low temperatures	Hardy
Wind	Tolerant
Drought	Moderately sensitive
Waterlogging	Sensitive
Soil types	Wide range, favours base-rich, damp but well-drained soils
Slope and aspect	Avoid north facing
Shade tolerance	Favours full sun, but shade tolerant

Productivity		
Main products	Food	Nuts
	Wood	Fencing poles
	Biomass	Woodfuel
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Low ❍
	Acidification	Unknown
Shade cover impacts*	Size of shadow (full-grown)	Low ●
	Canopy density	Moderately dense ●
	Leaf emergence	Early ●
Livestock fodder benefits		Low (low crude protein, low digestibility) ●
Risks to farming operations		Suckering roots (rootstocks can mitigate this)
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Very low
	Long-term (60 yrs)	Very low
Native status		Native ●
Value to wildlife		Moderate, highest value leaf litter and epiphytes ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	Low ●
	Invertebrates	Low ●
	Vertebrates	Moderate to high (especially squirrels) ●
Climate resilience		Moderate ●

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Cider Gum (*Eucalyptus gunnii*)

Physical	
Typical systems	Lowland
Max. height	**25 to 34m**
Canopy cover	Ovoid >8m wide
Canopy density	Open
Root architecture	Poorly understood, potentially extensive
Growth rate	High to very high
Silviculture	
Establishment time	**10-20 years** to maximum height
Establishment requirements	Weed control
Management requirements	Minimal to no pruning
Longevity	Unknown
Rotation length	Typically **12 year** rotation
Approach to silviculture	Can be coppiced Can be pollarded
Tolerances	
High temperatures	Sensitive
Low temperatures	Hardy in most of UK, but susceptible to early frosts
Wind	Sensitive
Drought	Likely moderately sensitive
Waterlogging	Moderately sensitive to moderately tolerant
Soil types	Favours slightly acidic
Slope and aspect	Avoid exposed locations
Shade tolerance	Full sun

Productivity		
Main products	Food	-
	Wood	Timber, pulpwood, potentially very high yielding
	Biomass	Woodfuel
	Speciality	Oil
Impact on local soil quality	Nutrient and organic matter accumulation	Moderate ❍
	Acidification	Unknown
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Open ●
	Leaf emergence	Evergreen ●
Livestock fodder benefits		Limited evidence
Risks to farming operations		High risk of failure from wind-chill and frosts Highly flammable
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Very high
	Medium-term (40 yrs)	Very high
	Long-term (60 yrs)	Very high
Native status		Recent introduction (Neophyte – survivor) ●
Value to wildlife		Negligible, but some value for bees and other pollinators ●
Other environmental impacts		High water consumption
Resilience		
Pest/disease susceptibility	Diseases	Moderate ●
	Invertebrates	Low ●
	Vertebrates	Low ●
Climate resilience		Moderate to high ●

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Beech (*Fagus sylvatica*)

Physical	
Typical systems	Pasture Arable Lowland to upland
Max. height	Typically up to **35m**, exceptionally 43m
Canopy cover	Globular to broad ovoid >8m wide
Canopy density	Dense
Root architecture	Shallow to moderate, extensive
Growth rate	Moderate
Silviculture	
Establishment time	**20-50 years** to maximum height
Establishment requirements	Weed control
Management requirements	Minimal to no pruning
Longevity	Typically up to **150-300 years**, exceptionally 900 years
Rotation length	Typically **70-80 year** timber rotation, exceptionally 100-140 years
Approach to silviculture	Coppices weakly Can be pollarded
Tolerances	
High temperatures	Sensitive
Low temperatures	Hardy, but susceptible to early and late frosts
Wind	Tolerant, but benefits from shelter when young
Drought	Moderately sensitive
Waterlogging	Sensitive
Soil types	Wide range, but requires moderate moisture levels
Slope and aspect	Any
Shade tolerance	Full sun to at least partial shade

Productivity		
Main products	Food	-
	Wood	Timber, moderate yielding
	Biomass	Woodfuel
	Speciality	Oil from nuts
Impact on local soil quality	Nutrient and organic matter accumulation	Moderate ❍
	Acidification	High ●
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Dense ●
	Leaf emergence	Early ●
Livestock fodder benefits		Low to moderate (moderate crude protein and micronutrients) ●
Risks to farming operations		Potentially very large tree
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Moderate
	Long-term (60 yrs)	Moderate
Native status		Native ●
Value to wildlife		High, especially for mycorrhizal fungi, wood-decay fungi and invertebrates, seeds, epiphytes ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	Moderate ●
	Invertebrates	Moderate ●
	Vertebrates	High (especially squirrels) ●
Climate resilience		Low to moderate ●

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Black Walnut (*Juglans nigra*)

Physical			
Typical systems	Arable	Pasture	Lowland
Max. height	Typically up to **30m**, exceptionally 50m		
Canopy cover	Globular, domed		>8m wide
Canopy density	Moderate		
Root architecture	Deep		
Growth rate	Moderate		
Silviculture			
Establishment time	**>50 years** to maximum height, 10 years for commercial nut yields		
Establishment requirements	Formative pruning		Weed control
Management requirements	High pruning for timber		
Longevity	Unknown		
Rotation length	Typically **60 year** timber rotation		
Approach to silviculture	Can be coppiced		Can be pollarded
Tolerances			
High temperatures	Tolerant		
Low temperatures	Hardy, but susceptible to late frosts		
Wind	Highly sensitive		
Drought	Moderately sensitive		
Waterlogging	Sensitive		
Soil types	Somewhat demanding, favours deep, well-drained, fertile soils		
Slope and aspect	Favours south / south-west, sheltered locations. Avoid north facing.		
Shade tolerance	Full sun		

Productivity		
Main products	Food	Nuts, more difficult to de-shell than *J. regia*
	Wood	High value timber, moderately high yielding. Vigorous hybrids available (likely lower value)
	Biomass	-
	Speciality	Dye, oil
Impact on local soil quality	Nutrient and organic matter accumulation	High ❍
	Acidification	Low ❍
Shade cover impacts*	Size of shadow (full-grown)	Moderate ●
	Canopy density	Moderate ●
	Leaf emergence	Late ●
Livestock fodder benefits		Moderate to high (high crude protein, moderate digestibility) ● Risk of toxicity to horses from wood shavings and leaf ingestion, and all animals from mouldy walnuts
Risks to farming operations		Allelopathic toxicity to many other plants Limited climatic suitability at present
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Moderate
	Medium-term (40 yrs)	Moderate
	Long-term (60 yrs)	Relatively low
Native status		Recent introduction (Neophyte – naturalised) ●
Value to wildlife		Relatively low, greatest value for mycorrhizal fungi and leaf litter ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	Moderate to high ●
	Invertebrates	Moderate ●
	Vertebrates	High (especially squirrels) ●
Climate resilience		High ●

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Walnut (*Juglans regia*)

Physical				
Typical systems	Arable	Pasture	Lowland	
Max. height	**20-30m**			
Canopy cover	Globular to ovoid or domed (conical when young)	Up to 15m wide		
Canopy density	Moderate			
Root architecture	Very deep			
Growth rate	Moderate			
Silviculture				
Establishment time	**20-50 years** to maximum height, nut yields after 5 to 6 years			
Establishment requirements	Staking	Irrigation	Formative pruning for timber	Weed control
Management requirements	High pruning for timber			
Longevity / rotation length	150-280 years			
Rotation length	Typically 60 years, exceptionally 30 years			
Approach to silviculture	Can be pollarded			
Tolerances				
High temperatures	Tolerant			
Low temperatures	Hardy, but sensitive to unseasonable frosts (some varieties have improved frost resistance)			
Wind	Sensitive (flowers and foliage)			
Drought	Moderately sensitive			
Waterlogging	Sensitive			
Soil types	Demanding; favours well-drained, deep, fertile, alkaline loam			
Slope and aspect	Avoid exposed locations			
Shade tolerance	Full sun. Light shade tolerated in early development			

Productivity		
Main products	Food	Nuts (typically using specific varieties)
	Wood	High-value timber or sawnwood, relatively low yielding. Vigorous hybrids available (likely lower value).
	Biomass	-
	Speciality	Oil, dye
Impact on local soil quality	Nutrient and organic matter accumulation	High ❍
	Acidification	Low ❍
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Moderate ●
	Leaf emergence	Late ●
Livestock fodder benefits		Moderate to high (high protein content, moderate digestibility) ● Risk of toxicity to horses from wood shavings, and all animals from mouldy walnuts
Risks to farming operations		Allelopathic toxicity to other plants, particularly affecting tomatoes and apples Limited climatic suitability at present
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Moderate
	Medium-term (40 yrs)	Moderate
	Long-term (60 yrs)	Relatively low
Native status		Long-established (Archaeophyte – cultivated) ●
Value to wildlife		Relatively low, highest value for mycorrhizal fungi and leaf litter ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	Low ●
	Invertebrates	Low, although nuts susceptible to pest damage ●
	Vertebrates	High (especially squirrels) ●
Climate resilience		High ●

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Apple (*Malus domestica*)

Physical				
Typical systems	Arable	Pasture	Lowland	
Max. height	Depends on cultivar and rootstock			
Canopy cover	Ovoid to irregular crown	Spread depends on cultivar / rootstock		
Canopy density	Moderate			
Root architecture	Depends on cultivar and rootstock, generally very deep for its size			
Growth rate	Generally moderate (depends on cultivar and rootstock)			
Silviculture				
Establishment time	Full cropping in **3-9 years** (depending on cultivar and rootstock)			
Establishment requirements	Staking	Formative pruning	Water during drought	Protection from browsing
Management requirements	Annual pruning			
Longevity	Depends on cultivar and rootstock			
Rotation length	**12-45 years**, depending on cultivar and rootstock			
Approach to silviculture	Orchard tree			
Tolerances				
High temperatures	Tolerant			
Low temperatures	Sensitive to frost pockets			
Wind	Sensitive			
Drought	Moderately sensitive			
Waterlogging	Sensitive			
Soil types	Wide range, avoid poorly drained or shallow soils			
Slope and aspect	Sunny and sheltered			
Shade tolerance	Full sun			

Productivity		
Main products	Food	Fruits (inc. eating, cooking, cider)
	Wood	Speciality timber
	Biomass	Limited woodfuel from pruning
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Moderate ❍
	Acidification	Unknown
Shade cover impacts*	Size of shadow (full-grown)	Low, but depends on rootstock/variety ●
	Canopy density	Moderate ●
	Leaf emergence	Early ●
Livestock fodder benefits		High (especially fruits and pomace) ●
Risks to farming operations		None known
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Very low
	Long-term (60 yrs)	Very low
Native status		Long-established (Archaeophyte – denizen or cultivated) ●
Value to wildlife		High, especially for foliage invertebrates, leaf litter, pollen & nectar, fruits ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	Generally high (varies according to variety and rootstock) ●
	Invertebrates	Generally high (varies according to variety and rootstock) ●
	Vertebrates	Moderate ●
Climate resilience		Moderate ●

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Scots Pine (*Pinus sylvestris*)

Physical	
Typical systems	Arable Pasture Lowland to upland
Max. height	**35-40m**
Canopy cover	Conical, broadening with age >8m wide
Canopy density	Dense
Root architecture	Deep
Growth rate	Low
Silviculture	
Establishment time	**20-50 years** to maximum height
Establishment requirements	Protection from browsing
Management requirements	Regular pruning for timber
Longevity	**250-400 years**
Rotation length	Typically **50-60 year** timber rotation, up to 100 years
Approach to silviculture	High forest tree
Tolerances	
High temperatures	Tolerant
Low temperatures	Very hardy
Wind	Tolerant
Drought	Tolerant
Waterlogging	Moderately sensitive to moderately tolerant
Soil types	Favours well-drained, non-calcareous soils, tolerant of poor fertility
Slope and aspect	Any
Shade tolerance	Favours full sun especially when young

Productivity		
Main products	Food	Nuts
	Wood	Diverse timber uses, high yielding
	Biomass	-
	Speciality	Resin, pine oil, Christmas trees
Impact on local soil quality	Nutrient and organic matter accumulation	Low ❍
	Acidification	High ●
Shade cover impacts*	Size of shadow (full-grown)	Moderate ●
	Canopy density	Dense ●
	Leaf emergence	Evergreen ●
Livestock fodder benefits		Moderate ●
Risks to farming operations		Capable of becoming very large Can aggressively regenerate from seeds Flammable
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Relatively low
	Long-term (60 yrs)	Moderate
Native status		Native (in Scotland) ●
Value to wildlife		Moderate, greatest value for mycorrhizal fungi ●
Other environmental impacts		High water consumption Can increase acidification of nearby watercourses, especially in dry areas
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Moderate ●
	Vertebrates	High ●
Climate resilience		Moderate ●

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Black-poplar (*Populus nigra* ssp. *betulifolia*)

Physical			
Typical systems	Arable	Pasture	Lowland
Max. height	**30-40m**		
Canopy cover	Spreading, ovoid to irregular		>8m wide
Canopy density	Moderately dense		
Root architecture	Moderate to deep, vigorously suckering		
Growth rate	High		
Silviculture			
Establishment time	**20-50 years** to maximum height		
Establishment requirements	Protection from browsing		
Management requirements	Regular pruning for timber		Sucker removal in autumn/winter
Longevity	**200-300+ years**		
Rotation length	Typically **6-20 years**		
Approach to silviculture	Can be coppiced		Can be pollarded
Tolerances			
High temperatures	Moderately tolerant to tolerant		
Low temperatures	Hardy		
Wind	Tolerant		
Drought	Sensitive to moderately sensitive		
Waterlogging	Moderately tolerant to tolerant		
Soil types	Favours lowland floodplains, especially loam, chalk or sand		
Slope and aspect	Any		
Shade tolerance	Full sun to partial shade		

Productivity		
Main products	Food	-
	Wood	Low-quality timber, high yielding
	Biomass	Charcoal
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	High ❍
	Acidification	Low to moderate ❍
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Moderately dense ●
	Leaf emergence	Early ●
Livestock fodder benefits		Likely moderate (moderately high crude protein content) ❍
Risks to farming operations		Vigorous, suckering roots Risk of overwintering aphid pests of vegetables
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Very high
	Medium-term (40 yrs)	Very high
	Long-term (60 yrs)	Very high
Native status		Native ●
Value to wildlife		Relatively low, but of high value as an endangered native tree, greatest value for foliage invertebrates ◍
Other environmental impacts		High water consumption in wet conditions High potential to reduce nutrient leaching
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Moderate ●
	Vertebrates	High ●
Climate resilience		Moderate ◍

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Hybrid Poplars (*Populus* spp.)

Physical	
Typical systems	Arable Pasture Lowland
Max. height	Depends on variety
Canopy cover	Depends on variety
Canopy density	Depends on variety
Root architecture	Moderate to deep, extensive surface roots
Growth rate	Very high
Silviculture	
Establishment time	Depends on variety
Establishment requirements	Weed control
Management requirements	Regular pruning
Longevity	N/A, harvested on rapid rotation
Rotation length	Typically **30-40 years**, exceptionally 22 years
Approach to silviculture	High forest tree
Tolerances	
High temperatures	Tolerant
Low temperatures	Susceptible to late frosts
Wind	Moderately tolerant but benefits from shelter
Drought	Sensitive (in terms of reducing growth rate)
Waterlogging	Sensitive (in terms of reducing growth rate)
Soil types	Demanding in terms of rapid growth, requiring highly fertile, base-rich, well-drained and aerated soils
Slope and aspect	Any
Shade tolerance	Full sun

Productivity		
Main products	Food	-
	Wood	Timber, potentially very high yielding
	Biomass	Bioenergy
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Moderate ❍
	Acidification	Low to moderate ❍
Shade cover impacts*	Size of shadow (full-grown)	Moderate to high (depends on variety) ●
	Canopy density	Depends on variety
	Leaf emergence	Early ●
Livestock fodder benefits		Likely moderate ❍
Risks to farming operations		Risk of overwintering aphid pests of vegetables
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Very high
	Medium-term (40 yrs)	Very high
	Long-term (60 yrs)	Very high
Native status		Hybrids typically derived from non-native species ●
Value to wildlife		Relatively low, greatest value for foliage invertebrates◍
Other environmental impacts		High water consumption in wet conditions High potential to reduce nutrient leaching
Resilience		
Pest/disease susceptibility	Diseases	High (but depends on variety) ●
	Invertebrates	High (but depends on variety) ●
	Vertebrates	High ●
Climate resilience		Moderate to high (depending on variety) ❍

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Aspen (*Populus tremula*)

Physical	
Typical systems	Arable Pasture Lowland to upland
Max. height	**18-40m**
Canopy cover	Ovoid to globular, slightly conical >8m wide
Canopy density	Light to moderately dense
Root architecture	Moderate to deep, abundant suckers
Growth rate	High
Silviculture	
Establishment time	**20-50 years** to maximum height
Establishment requirements	Protection from browsing
Management requirements	Minimal to no pruning, self-prunes well
Longevity	Up to **100 years**
Rotation length	Coppice rotation of **20 years** for pulpwood
Approach to silviculture	Coppices well within first 5 years
Tolerances	
High temperatures	Sensitive
Low temperatures	Very hardy
Wind	Tolerant
Drought	Moderately sensitive
Waterlogging	Moderately sensitive to tolerant
Soil types	Wide range, favours free-draining mineral soils
Slope and aspect	Any
Shade tolerance	Full sun to partial shade

Productivity		
Main products	Food	-
	Wood	Timber – veneers, pulp, charcoal, potentially high yielding
	Biomass	Potential for biomass where growth is rapid
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Moderate ❍
	Acidification	Low to moderate ❍
Shade cover impacts*	Size of shadow (full-grown)	Moderate ●
	Canopy density	Light to moderately dense ●
	Leaf emergence	Late ●
Livestock fodder benefits		Moderate ❍
Risks to farming operations		Abundant root suckers, can damage drains and buildings
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	High
	Medium-term (40 yrs)	High
	Long-term (60 yrs)	High
Native status		Native ●
Value to wildlife		Relatively low, greatest value for foliage invertebrates ●
Other environmental impacts		High water consumption in wet conditions High potential to reduce nutrient leaching
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Moderate ●
	Vertebrates	High ●
Climate resilience		Moderate to high ●

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Wild Cherry (*Prunus avium*)

Physical	
Typical systems	Arable Pasture Lowland
Max. height	Typically up to **25m**, exceptionally 32m
Canopy cover	Domed, globular to broad ovoid c.8m wide or more
Canopy density	Moderately dense
Root architecture	Moderate, becoming shallower with age, suckering
Growth rate	Moderate to high
Silviculture	
Establishment time	**20-50 years** to maximum height, fruit yields within 5-6 years
Establishment requirements	Weed control
Management requirements	High pruning for timber
Longevity	Up to **100 years** or more
Rotation length	**40-80 years** for timber
Approach to silviculture	Coppices poorly
Tolerances	
High temperatures	Moderately sensitive
Low temperatures	Hardy, but flowers can be damaged by late frosts
Wind	Conflicting information
Drought	Moderately sensitive
Waterlogging	Sensitive
Soil types	Well drained, favouring deep fertile soils
Slope and aspect	Avoid exposed locations
Shade tolerance	Full sun, shade tolerated when very young

Productivity		
Main products	Food	Fruits
	Wood	High-value timber, high yielding
	Biomass	-
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Moderate ❍
	Acidification	Low ❍
Shade cover impacts*	Size of shadow (full-grown)	Moderate ●
	Canopy density	Moderately dense ●
	Leaf emergence	Early ●
Livestock fodder benefits		Risk of toxicity ●
Risks to farming operations		Root suckers Risk of toxicity to other plants, including potatoes, wheat, plum Liable to windthrow and heartrot, especially >60 years
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	High
	Medium-term (40 yrs)	High
	Long-term (60 yrs)	High
Native status		Native ●
Value to wildlife		Moderate, greatest value for fruits and seeds ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Moderate ●
	Vertebrates	Moderate to high ●
Climate resilience		Moderate ●

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Plum (*Prunus domestica* ssp. *domestica*)

Physical	
Typical systems	Arable Pasture Lowland
Max. height	Depends on variety and rootstock
Canopy cover	Globular Spread depends on variety and rootstock
Canopy density	Moderately dense
Root architecture	Shallow and suckering, depending on rootstock
Growth rate	Moderate
Silviculture	
Establishment time	**5-10 years** to maximum height, fruit yields within 4-5 years, full production 7-9 years
Establishment requirements	Formative pruning Shelter Irrigation
Management requirements	Annual pruning in spring to early summer
Longevity	Unknown
Rotation length	**25-35 years**
Approach to silviculture	Orchard tree
Tolerances	
High temperatures	Tolerant
Low temperatures	Hardy in most of UK
Wind	Sensitive
Drought	Tolerant
Waterlogging	Sensitive
Soil types	Favours sand or clay, acid to neutral, well-drained soils
Slope and aspect	South or west facing, sheltered
Shade tolerance	Full sun

Productivity		
Main products	Food	Fruits – inc. fresh, dehydrated, canned, processed
	Wood	Speciality timber
	Biomass	Limited woodfuel from pruning
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Low ❍
	Acidification	High ❍
Shade cover impacts*	Size of shadow (full-grown)	Low ●
	Canopy density	Moderately dense ●
	Leaf emergence	Early ●
Livestock fodder benefits		Moderate (undersized fruits used for feed) ● Risk of toxicity in other plant parts
Risks to farming operations		Root suckers (can be mitigated through appropriate rootstocks)
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Very low
	Long-term (60 yrs)	Very low
Native status		Long-established (Archaeophyte – denizen or cultivated) ●
Value to wildlife		Moderate, greatest value for leaf litter, pollen & nectar, and fruits ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	High ●
	Vertebrates	Moderate ●
Climate resilience		Moderate ●

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Bird Cherry (*Prunus padus*)

Physical	
Typical systems	Pasture Lowland to semi-upland
Max. height	**15-21m**
Canopy cover	Spreading, domed and ovoid (conical when young) 4-8m wide
Canopy density	Light to moderately dense
Root architecture	Shallow and suckering
Growth rate	Moderate to high
Silviculture	
Establishment time	**20-50 years** to maximum height
Establishment requirements	Minimal
Management requirements	Prune in mid-summer if silver leaf problematic
Longevity	**60 to 100+ years**
Rotation length	No typical rotation
Approach to silviculture	Can be coppiced Can be pollarded
Tolerances	
High temperatures	Tolerant
Low temperatures	Hardy
Wind	Conflicting information
Drought	Moderately sensitive
Waterlogging	Moderately tolerant
Soil types	Wide range, favours well-drained damp soils
Slope and aspect	Any
Shade tolerance	Full sun to partial shade

Productivity		
Main products	Food	Fruits – inc. for jams, liquer
	Wood	Speciality timber
	Biomass	-
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Low ❍
	Acidification	Low ❍
Shade cover impacts*	Size of shadow (full-grown)	Low ●
	Canopy density	Light to moderately dense ●
	Leaf emergence	Early ●
Livestock fodder benefits		Risk of toxicity ●
Risks to farming operations		Root suckers
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Very low
	Long-term (60 yrs)	Very low
Native status		Native ●
Value to wildlife		Moderate, greatest value for fruits and seeds ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	Moderate (high future risk) ●
	Invertebrates	Moderate ●
	Vertebrates	Low to moderate ●
Climate resilience		Low ●

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Pear (*Pyrus communis*)

Physical			
Typical systems	Arable	Pasture	Lowland
Max. height	Depends on variety and rootstock		
Canopy cover	Upright and slender to ovoid		Spread depends on variety and rootstock
Canopy density	Dense		
Root architecture	Generally deep, depending on variety and rootstock		
Growth rate	Low to moderate		
Silviculture			
Establishment time	Full cropping in **3-9 years** (depending on cultivar and rootstock)		
Establishment requirements	Staking	Formative pruning	Water during drought
Management requirements	Annual pruning recommended		
Longevity	Potentially 200 to 300 years, depends on cultivar and rootstock		
Rotation length	**15-40 years**, depending on cultivar and rootstock		
Approach to silviculture	Orchard tree		
Tolerances			
High temperatures	Tolerant		
Low temperatures	Hardy		
Wind	Sensitive		
Drought	Moderately sensitive to moderately tolerant		
Waterlogging	Sensitive		
Soil types	Wide range, favours well-drained with at least moderate fertility, avoid very acid soils		
Slope and aspect	South or west facing, sheltered		
Shade tolerance	Full sun, especially when young		

Productivity		
Main products	Food	Fruits (inc. fresh, canned, dried, juiced)
	Wood	Speciality timber
	Biomass	Limited woodfuel from pruning
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Moderate ❍
	Acidification	Unknown
Shade cover impacts*	Size of shadow (full-grown)	Low, but depends on rootstock/variety ●
	Canopy density	Dense ●
	Leaf emergence	Early ●
Livestock fodder benefits		Moderate ❍
Risks to farming operations		None known
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Very low
	Long-term (60 yrs)	Very low
Native status		Long-established (Archaeophyte – cultivated) ●
Value to wildlife		High, especially for foliage invertebrates, leaf litter, pollen & nectar ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	High ●
	Vertebrates	Moderate ●
Climate resilience		Moderate ●

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● = high confidence, ● = moderate confidence, ❍ = low confidence

Sessile Oak (*Quercus petraea*)

Physical			
Typical systems	Arable	Pasture	Lowland to upland
Max. height	Typically up to **27m**, exceptionally 40m		
Canopy cover	Globular to broad ovoid, domed		>8m wide, potentially very wide
Canopy density	Moderately dense		
Root architecture	Deep		
Growth rate	Low to moderate		
Silviculture			
Establishment time	**>50 years** to maximum height		
Establishment requirements	Weed control	Protection from browsing	Formative pruning
Management requirements	High pruning for good quality timber		
Longevity	Typically **400-500 years**, potentially 600 to 1000+ years		
Rotation length	15-25 years coppice, 120-160 years sawn-wood or veneer		
Approach to silviculture	Can be coppiced (esp. in south)		Can be pollarded
Tolerances			
High temperatures	Tolerant		
Low temperatures	Very hardy, but occasionally damaged by late frosts		
Wind	Tolerant		
Drought	Moderately tolerant		
Waterlogging	Sensitive		
Soil types	Wide range, favours well-drained somewhat acid soils		
Slope and aspect	Any		
Shade tolerance	Full sun to partial shade		

Productivity		
Main products	Food	-
	Wood	High value timber (inc. sawnwood, veneers, plywood), relatively low yielding
	Biomass	Woodfuel
	Speciality	Acorn flour, various medicinal products
Impact on local soil quality	Nutrient and organic matter accumulation	High ❍
	Acidification	High ●
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Moderately dense ●
	Leaf emergence	Late ●
Livestock fodder benefits		Moderate (moderate crude protein, low minerals) ● Risk of toxicity from buds, young leaves and acorns
Risks to farming operations		Capable of becoming very large tree Timber very prone to defects
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Moderate
	Medium-term (40 yrs)	Moderate
	Long-term (60 yrs)	Low
Native status		Native ●
Value to wildlife		Very high, especially for mycorrhizal fungi, wood-decay fungi and invertebrates, foliage invertebrates, seeds, and epiphytes ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Moderate ●
	Vertebrates	High ●
Climate resilience		Low to moderate ●

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Pedunculate Oak (*Quercus robur*)

Physical			
Typical systems	Arable	Pasture	Lowland
Max. height	Typically up to **27m**, exceptionally 40m		
Canopy cover	Globular to broad ovoid, domed		>8m wide, potentially very wide
Canopy density	Moderate to moderately dense		
Root architecture	Deep to very deep, more lateral roots on shallow soils		
Growth rate	Low		
Silviculture			
Establishment time	**20-50 years** to maximum height		
Establishment requirements	Weed control	Protection from browsing	Formative pruning
Management requirements	High pruning for good quality timber		
Longevity	Typically **400-500 years**, potentially 600 to 1000+ years		
Rotation length	15-25 years coppice, 120 or more years sawn-wood or veneer		
Approach to silviculture	Can be coppiced (esp. in south)		Can be pollarded
Tolerances			
High temperatures	Moderately tolerant		
Low temperatures	Hardy, but occasionally damaged by late frosts		
Wind	Tolerant when established		
Drought	Moderately sensitive to sensitive		
Waterlogging	Moderately sensitive to moderately tolerant		
Soil types	Wide range, favours well-drained but heavy, somewhat base-rich soils		
Slope and aspect	Any		
Shade tolerance	Full sun (especially when young) to partial shade		

Productivity		
Main products	Food	-
	Wood	High value timber (inc. sawnwood, veneers, plywood), relatively low yielding
	Biomass	Woodfuel
	Speciality	Acorn flour, various medicinal products
Impact on local soil quality	Nutrient and organic matter accumulation	High (planted for soil improvement and land restoration) ●
	Acidification	High ●
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Moderate to moderately dense ●
	Leaf emergence	Late ●
Livestock fodder benefits		Moderate (moderate crude protein, low minerals) ● Acorns historically important for pig forage Risk of toxicity from buds, young leaves and acorns
Risks to farming operations		Capable of becoming very large tree Timber very prone to defects
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Moderate
	Medium-term (40 yrs)	Moderate
	Long-term (60 yrs)	Low
Native status		Native ●
Value to wildlife		Very high, especially for mycorrhizal fungi, wood-decay fungi and invertebrates, foliage invertebrates, seeds, and epiphytes ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Moderate ●
	Vertebrates	High ●
Climate resilience		Low to moderate ●

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Red Oak (*Quercus rubra*)

Physical	
Typical systems	Arable Pasture Lowland
Max. height	Typically up to **20m**, exceptionally 35m
Canopy cover	Globular to broad ovoid >8m wide, potentially >10m
Canopy density	Moderately dense
Root architecture	Likely deep
Growth rate	Moderate to high
Silviculture	
Establishment time	**20-50 years** to maximum height
Establishment requirements	Minimal
Management requirements	High pruning
Longevity	Typically **100 years**, potentially 200 years
Rotation length	Typically **70-120 years**
Approach to silviculture	Coppices well
Tolerances	
High temperatures	Tolerant
Low temperatures	Very hardy, but occasionally damaged by late frosts
Wind	Tolerant
Drought	Moderately sensitive to tolerant; drought likely to damage timber
Waterlogging	Sensitive
Soil types	Well-drained chalk, sand or clay, favours acid sandy loams
Slope and aspect	Avoid north facing
Shade tolerance	Full sun to partial shade

Productivity		
Main products	Food	-
	Wood	Timber, lower value than native oaks, relatively low yielding
	Biomass	Woodfuel
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	High ❍
	Acidification	High ❍
Shade cover impacts*	Size of shadow (full-grown)	Moderate ●
	Canopy density	Moderately dense ●
	Leaf emergence	Late ●
Livestock fodder benefits		Low ❍ Risk of toxicity from buds, young leaves and acorns
Risks to farming operations		Capable of becoming very large tree Timber very prone to defects
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Relatively low
	Long-term (60 yrs)	Relatively low
Native status		Recent introduction (Neophyte – naturalised) ●
Value to wildlife		Moderate to high ❍
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	Moderate ●
	Invertebrates	Low to moderate ●
	Vertebrates	High ❍
Climate resilience		High ●

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White Willow (*Salix alba*)

Physical	
Typical systems	Arable Pasture Lowland
Max. height	25-33m
Canopy cover	Irregular, broadly columnar >8m wide
Canopy density	Open
Root architecture	Extensive, shallow to deep, shallower in wet soils
Growth rate	High
Silviculture	
Establishment time	**20-50 years** to maximum height
Establishment requirements	Protection from browsing Weed control
Management requirements	Strict pruning requirements for timber
Longevity	Typically **20-30 years**, exceptionally 200+ years
Rotation length	Timber rotation of 12-20 years for subspecies *caerulea*
Approach to silviculture	Can be coppiced Can be pollarded
Tolerances	
High temperatures	Moderately tolerant
Low temperatures	Hardy
Wind	Tolerant
Drought	Sensitive
Waterlogging	Tolerant
Soil types	Wide range of damp soils, favouring fertile and base-rich
Slope and aspect	Any
Shade tolerance	Full sun

Productivity		
Main products	Food	-
	Wood	Timber (usually subspecies *caerulea*), inc. plywood, pulpwood, posts; relatively low yielding
	Biomass	Fuelwood
	Speciality	Tannins, edible truffles
Impact on local soil quality	Nutrient and organic matter accumulation	Low to moderate ❍
	Acidification	Low to moderate ❍
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Open ●
	Leaf emergence	Early ●
Livestock fodder benefits		Moderate to high (high protein content, moderate digestibility) ●
Risks to farming operations		Risk of blocking drains Winter host of carrot aphid
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Moderate
	Medium-term (40 yrs)	Moderate
	Long-term (60 yrs)	Relatively low
Native status		Long-established (Archaeophyte – denizen) ●
Value to wildlife		Moderate, greatest value for pollen & nectar ●
Other environmental impacts		High water consumption in wet conditions High potential to reduce nutrient leaching
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	High ●
	Vertebrates	Moderate to high ●
Climate resilience		Low ❍

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Goat Willow (*Salix caprea*)

Physical	
Typical systems	Arable Pasture Lowland or upland
Max. height	Typically up to **10m**, exceptionally 20m
Canopy cover	Irregular, bushy 4-8m wide
Canopy density	Open
Root architecture	Extensive, moderate depth
Growth rate	Moderate to high
Silviculture	
Establishment time	**20-50 years** to maximum height
Establishment requirements	Protection from browsing Weed control
Management requirements	Minimal to no pruning
Longevity	60 to 100+ years
Rotation length	5-12 years
Approach to silviculture	Coppices well
Tolerances	
High temperatures	Moderately tolerant
Low temperatures	Hardy
Wind	Tolerant
Drought	Moderately sensitive
Waterlogging	Moderately sensitive
Soil types	Deep, moist, well-drained
Slope and aspect	Any
Shade tolerance	Full sun to partial shade

Productivity		
Main products	Food	-
	Wood	Speciality timber
	Biomass	Fuelwood, charcoal
	Speciality	Tannins and dye from bark
Impact on local soil quality	Nutrient and organic matter accumulation	Low ❍
	Acidification	Low to moderate ❍
Shade cover impacts*	Size of shadow (full-grown)	Low ●
	Canopy density	Open ●
	Leaf emergence	Early ●
Livestock fodder benefits		Moderate to high (high protein content, moderate digestibility) ●
Risks to farming operations		Risk of blocking drains
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Very low
	Long-term (60 yrs)	Very low
Native status		Native ●
Value to wildlife		High, especially for foliage invertebrates, pollen & nectar ●
Other environmental impacts		High water consumption in wet conditions High potential to reduce nutrient leaching
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	High ●
	Vertebrates	Moderate to high ●
Climate resilience		Moderate to high ❍

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Grey Willow (*Salix cinerea*)

Physical	
Typical systems	Arable Pasture Lowland or upland
Max. height	Typically up to **8m**, exceptionally 17m
Canopy cover	Irregular 2.5-4m wide
Canopy density	Open
Root architecture	Extensive, moderate depth
Growth rate	High
Silviculture	
Establishment time	**5-10 years** to maximum height
Establishment requirements	Protection from browsing Weed control
Management requirements	Minimal to no pruning
Longevity	Up to 100+ years
Rotation length	12-15 years, or short rotation of 2-3 years
Approach to silviculture	Can be coppiced
Tolerances	
High temperatures	Moderately tolerant
Low temperatures	Very hardy
Wind	Tolerant
Drought	Sensitive
Waterlogging	Tolerant
Soil types	Wet and damp soils, favours well-drained chalk, sand or clay
Slope and aspect	Avoid north facing
Shade tolerance	Full sun, more shade tolerant in waterlogged sites

Productivity		
Main products	Food	-
	Wood	-
	Biomass	Fuelwood
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Low ❍
	Acidification	Low to moderate ❍
Shade cover impacts*	Size of shadow (full-grown)	Low ●
	Canopy density	Open ●
	Leaf emergence	Early ●
Livestock fodder benefits		Moderate to high ❍
Risks to farming operations		Risk of blocking drains
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Very low
	Long-term (60 yrs)	Very low
Native status		Native ●
Value to wildlife		High, especially for foliage invertebrates, pollen & nectar ●
Other environmental impacts		High water consumption in wet conditions High potential to reduce nutrient leaching
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	High ●
	Vertebrates	Moderate to high ●
Climate resilience		Low ❍

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Willow varieties for SRC (*Salix* spp.)

Physical	
Typical systems	Arable Pasture Lowland or upland (depends on variety)
Max. height	Depends on variety
Canopy cover	Irregular, bushy <4m wide
Canopy density	Open
Root architecture	Extensive, moderate depth
Growth rate	High
Silviculture	
Establishment time	First-year growth typically coppiced
Establishment requirements	Protection from browsing Weed control
Management requirements	Good yields require high inputs of fertiliser, herbicides and pesticides
Longevity	22 to 30 years
Rotation length	2-5 years, typically 3 years
Approach to silviculture	Short-rotation coppice
Tolerances	
High temperatures	Tolerant
Low temperatures	Hardy
Wind	Potentially sensitive
Drought	Sensitive
Waterlogging	Sensitive to frequent waterlogging
Soil types	Wide range, but avoid free-draining sandy soils and high organic peaty soils (due to weed competition)
Slope and aspect	Any
Shade tolerance	Full sun

Productivity		
Main products	Food	-
	Wood	-
	Biomass	Bioenergy, high yielding
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Low ❍
	Acidification	Low to moderate ❍
Shade cover impacts*	Size of shadow (full-grown)	Low ●
	Canopy density	Open ●
	Leaf emergence	Early ●
Livestock fodder benefits		Moderate to high ❍
Risks to farming operations		Risk of blocking drains
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	High
	Medium-term (40 yrs)	N/A
	Long-term (60 yrs)	N/A
Native status		Hybrids, typically derived from non-native species ●
Value to wildlife		Moderate, greatest value for pollen & nectar ❍
Other environmental impacts		High water consumption in wet conditions High potential to reduce nutrient leaching
Resilience		
Pest/disease susceptibility	Diseases	High (but depends on variety) ●
	Invertebrates	High (but depends on variety) ●
	Vertebrates	Moderate to high ●
Climate resilience		Moderate ●

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Rowan (*Sorbus aucuparia*)

Physical	
Typical systems	Arable Pasture Lowland or upland
Max. height	Typically up to **15m**, exceptionally 22m
Canopy cover	Ovoid to domed 4-8m wide
Canopy density	Open to moderately dense
Root architecture	Branching
Growth rate	Moderate
Silviculture	
Establishment time	**20-50 years** to maximum height
Establishment requirements	Protection from browsing Weed control
Management requirements	Minimal to no pruning
Longevity	Up to 200+ years
Rotation length	Not typically grown on rotation
Approach to silviculture	Coppices well
Tolerances	
High temperatures	Moderately sensitive
Low temperatures	Hardy to very hardy
Wind	Tolerant
Drought	Moderately sensitive
Waterlogging	Sensitive
Soil types	Wide range, favours moderately fertile, humus-rich uncompacted soil
Slope and aspect	Any
Shade tolerance	Full sun to partial shade, more shade tolerant when young

Productivity		
Main products	Food	Berries (inc. juicing, jelly, jams)
	Wood	Turnery and speciality timber, low yielding
	Biomass	Limited fuelwood
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	Low ❍
	Acidification	Low ❍
Shade cover impacts*	Size of shadow (full-grown)	Low ●
	Canopy density	Open to moderately dense ●
	Leaf emergence	Early ●
Livestock fodder benefits		Moderate to high (low crude protein, high digestibility) ●
Risks to farming operations		Winter host for cereal aphid
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	Relatively low
	Medium-term (40 yrs)	Very low
	Long-term (60 yrs)	Very low
Native status		Native ●
Value to wildlife		Moderate, greatest value for leaf litter, blossom, seeds ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	High ●
	Invertebrates	Moderate to high ●
	Vertebrates	High (especially deer) ●
Climate resilience		Low ●

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Small-leaved Lime (*Tilia cordata*)

Physical			
Typical systems	Arable	Pasture	Lowland
Max. height	20-37m		
Canopy cover	Broad ovoid to globular, more conical when young	>8m wide, potentially >15m	
Canopy density	Moderately dense to dense		
Root architecture	Conflicting information		
Growth rate	Moderate to high		
Silviculture			
Establishment time	**20-50 years** to maximum height		
Establishment requirements	Protection from browsing and rodents		
Management requirements	Minimal to no pruning		
Longevity	800+ years, potentially exceeding 1000 years if coppiced		
Rotation length	10-20 years coppice, 100-140 years timber		
Approach to silviculture	Coppices well	Can be pollarded	
Tolerances			
High temperatures	Moderately tolerant		
Low temperatures	Hardy to very hardy		
Wind	Sensitive		
Drought	Moderately sensitive, considerably reduces growth		
Waterlogging	Sensitive		
Soil types	Wide range, favours neutral to slightly alkaline, moist and fertile soils		
Slope and aspect	Favours valley bottoms with moist air, avoid exposed locations		
Shade tolerance	Full sun to partial shade or greater		

Productivity		
Main products	Food	-
	Wood	Timber, moderate yielding
	Biomass	-
	Speciality	-
Impact on local soil quality	Nutrient and organic matter accumulation	High (often planted as soil improver) ●
	Acidification	Low ●
Shade cover impacts*	Size of shadow (full-grown)	High ●
	Canopy density	Moderately dense to dense ●
	Leaf emergence	Late ●
Livestock fodder benefits		High (high nutritional value and digestibility) ●
Risks to farming operations		None known
Environmental impacts		
Carbon sequestration	Short-term (20 yrs)	High
	Medium-term (40 yrs)	High
	Long-term (60 yrs)	High
Native status		Native ●
Value to wildlife		Moderate, greatest value for mycorrhizal fungi, leaf litter, pollen & nectar ●
Other environmental impacts		None known
Resilience		
Pest/disease susceptibility	Diseases	Low to moderate ●
	Invertebrates	Moderate ●
	Vertebrates	High (especially browsing mammals) ●
Climate resilience		High ●

* Effect depends on system, likely benefits of shade in livestock systems but disbenefit in arable
● = high confidence, ● = moderate confidence, ❍ = low confidence

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