

# Tree Seed Species Strategies

## Introduction and Context

These species strategies were first developed by a team of technical experts as part of the Sustainable Seed Sourcing Project funded by the Nature for Climate Fund 2021-22 and have been further considered by Forest Research, Forestry Commission and [Natural England]. They provide suggested ideal approaches, based on species ecology and biology, to the delivery of enhanced quantity and diversity of registered Seed Stands and orchards for 21 species which have been identified as a priority for action. Guelder rose and wych elm were previously identified as priority species but have been removed as several projects to address these strategies are currently underway.

These strategies all seek to deliver additional or enhanced Seed Stands and Seed Orchards registered on the Forest Reproductive Materials Register of Basic Materials. A summary of the FRM Regulations and how to register stands and orchards on the register is available on the FRM website at [Marketing forest reproductive material for forestry purposes - GOV.UK \(www.gov.uk\)](https://www.gov.uk/guidance/marketing-forest-reproductive-material-for-forestry-purposes) and in this guidance <https://www.forestresearch.gov.uk/publications/forest-reproductive-material-regulations-controlling-seed-cuttings-and-planting-stock-for-forestry-in-great-britain-2nd-edition/> - Please note that this document is currently under review and a new guide will be available soon.

The list of priority species is based on a detailed review of the current entries on the Register of Basic Material and a high-level audit of their use, together with interviews with tree seed nurseries and seed suppliers to review existing and predicted future supply and demand of tree seed. These are the species highlighted as most likely to need support to enhance quality, quantity, and diversity of seed sources. This is an ongoing process, and the priority list may change in future.

The Strategies include information on each species which should be considered when developing approaches to seed sourcing and provide a recommended approach for each species based on this information. These strategies are intended to provide useful technical information and guidance to support those developing activities to enhance seed sourcing activities, including those seeking financial support through the FC Seed Sourcing Grant. However, they should not be considered prescriptive and alternative or adapted approaches may also be considered. In particular, further research may reveal that different numbers of individuals/populations/propagules are required to provide the material for Seed Orchard development. While these strategies recommend the identification and use of known, native origin populations as FRM basic material, FC also accepts registration of stands of unknown or known non-native origin on the FRM register of Basic Materials.

The strategies provide a GB-wide approach to developing seed sources.

Several of the Strategies refer to the possibility of using resources from the Millennium Seed Bank (MSB), managed by the Royal Botanic Gardens, Kew. The MSB holds multiple

seed collections of most native trees and shrubs, sampled from across the species' range in the UK. All collections have been made from autochthonous populations considered representative of national patterns of local adaptation to sites, with seed from individual maternal trees collected and stored separately. Detailed data relating to the collection site and population, seed processing, viability and germination conditions accompanies each collection. Most of these seed collections and summary data can be viewed via the UKFGR Interactive Map (<https://ukfgr.org/conservation-units/>) and may be available for use upon request to the Millennium Seed Bank, though the MSB needs advance discussion of the resourcing required to deliver such requests. To discuss this possibility, please contact [MSBUKSeeds@kew.org](mailto:MSBUKSeeds@kew.org) **before** completing funding applications.

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## Glossary

Terminology	Definition
<b>Basic Material</b>	The plant material from which Forest Reproductive Material (FRM) is derived from.
<b>Seed Source</b>	All material which may range from a single tree to any collection of trees within a region of provenance, or native seed zone.
<b>Seed Stand</b>	Specifically defined areas or groups of trees with identified boundaries.
<b>Seed Orchards and Parents of Families</b>	Planted using individuals derived from tree breeding programmes. The FRM produced will be seeds. Generally situated outside of the natural landscape in an area convenient for seed collectors.
<b>Clones and Clonal Mixtures</b>	Also planted using individuals from breeding programmes, but the FRM will be produced through vegetative propagation.
<b>Forest Reproductive Material (FRM)</b>	Can consist of fruits, seeds, and cones; all parts of plants obtained by vegetative propagation including embryos; and plants produced from any of these.
<b>Source-identified FRM</b>	Comes from general or specific locations within a single region of provenance or native seed zone with an altitude band but with no specific superior qualities recognised.
<b>Selected FRM</b>	Collected from stands showing superior characteristics, e.g., better form, growth rate, health.
<b>Qualified FRM</b>	Derives from the selection of superior individual trees which have not undergone any form of testing.
<b>Tested FRM</b>	Derives from the selection of individual trees or stands which have been evaluated for genetic quality or, in comparison to accepted standards, have been shown to be superior.
<b>Clonal Seed Orchard</b>	A Seed Orchard raised from selected clones propagated by grafting, cutting, air-layering or tissue culture.
<b>Seedling Seed Orchard</b>	A Seed Orchard raised from seedlings.
<b><i>In-situ</i></b>	Situated in the original place.

## Aspen (*Populus tremula* L.)

### 2021 Status

No registered Seed Stands, but over 100 approved or tested clonal material collections.

### Recommended Seed production approach(es):

Establish the resources to create clonal Seed Stands and Seed Orchards for lowland Britain.

- Identify 50 native lowland sites in southern Britain across Regions 30 and 40 (avoiding alien and hybrid populations where possible)
- Select and collect propagating material from up to four genotypes per site (noting details of the two best potential plus trees per site if present).
- Propagate at least three replicates of each tree and grow on as planting material for clonal Seed Stands and Seed Orchards. Further replicates would be useful for wider use.
- Assess flowering to identify male and female clones, and timing of flowering. Assign a minimum of 30 females and 30 males with overlapping flowering periods per Seed Stand, using the plus tree clones for the selected productive Seed Orchards.

### Deliverables

Establishment of a large and genetically diverse clonal aspen collection from a wide geographic range and different site types in southern Britain which can be used to create Seed Stands and Seed Orchards.

### Species information

#### Description

Native, fast growing, common, large, deciduous tree with light branches often quite perpendicular, giving to the crown a conic-pyramidal shape. Male catkins are 5-10cm long, grey-brown, yellowish. Female catkins are green, 5-6cm at pollination, extending 10-12cm long at maturity in early summer, bearing 50-80 capsules each containing numerous tiny seeds embedded in downy fluff. The bark is greenish-grey, smooth, wrinkled with diamond lenticels [1].

#### Distribution

Widespread and continuous across Britain. It has been planted for amenity, as food for browsing deer, shelterbelts, site remediation and afforestation. Increasingly planted for biomass. Found up to 0-640m [2].

#### Site characteristics

Grows on a wide range of soil types from dry, nutrient poor sands to nutrient rich, moist but not wet, clays. However, it is only moderately tolerant of exposure. It is a light depending, colonising, pioneer species. It frequently forms a component of ancient woodland where it can form dense, extensive clonal thickets/stands but regeneration

requires active management to create open space, bare ground and good light. Native in mixed broadleaf woodlands, hedgerows, on heathland, in disused clay- and sand- pits, and occasionally in pine woods. In the north and west, it grows on cliffs, rocky outcrops and riverbanks, often as a shrub. It suckers to form thickets, and readily colonises bare ground [2].

### Life history

**Dispersal:** Effective gene flow [3]. Wind pollinated. Seed dispersed by wind.

**Reproduction mode (s):** Sexual - obligate outcrossing. Dioecious. Significant seed set is infrequent. Asexual - very freely propagates clonally from root suckers.

**Sexual reproductive age:** 10+ years.

**Longevity:** Long lived. Up to 100 years as an individual tree, but can live as individual genotypes via root suckers, clones may live thousands of years if new suckers continuously arise from the original rootstock [4,5].

**Ploidy:** Diploid ( $2n=38$ ).

### Threats

**Fragmentation:** Potentially in parts of range. Plantings likely to obscure native range.

**Alien plantings:** Very widely planted in natural and domestic settings.

**Domestication:** Ornamental forms and varieties developed.

**Hybridisation:** Hybridises naturally with white poplar (*Populus alba*) forming the grey poplar (*Populus x canescens*), which is intermediate morphologically, but more vigorous than its parents. Artificial hybrids have been produced with other poplars: *P. tremula x tremuloides*, the hybrid with the North American quaking aspen (*Populus tremuloides*) is widely used for large-scale timber/biomass plantations.

**Clonal reproduction:** Very frequent. Primary means of reproduction. May form large and more continuous stands [5]. This should be a key consideration when selecting populations and sampling individuals.

**Major pests or diseases:** Leaf rusts of genus *Melampsora* can be damaging especially on younger trees.

### Adaptive variation

**Very limited UK data.** The silvicultural performance of aspen clones was assessed in five Scottish field trials established in 1993. These compared a range of aspen clones – chosen systematically without selecting for superior phenotypes – with selected hybrid Poplar cultivars and, in some cases, selected clones for an Aspen breeding programme in Sweden. After six years, survival and growth were found to vary between clones and sites. Examination of zonal performances did not provide conclusive evidence that local origins of aspen are necessarily the best adapted [6]. Some continental studies suggest the occurrence of high adaptive genetic variation in aspen, along altitudinal and latitudinal gradients [7].

### Genetic diversity

**Limited UK data.** The genetic diversity of European aspen is generally high with much of the diversity found within stands and less between them. This was also found in a Scottish study - genetic diversity of 275 Scottish aspen across six regional populations was studied using isoenzymes. Genetic diversity was found to be similar to other long lived woody

perennials but lower than other *Populus* species. Less than 2% of the genetic marker variation was accounted for by differences between these regions with only clones from southern region being somewhat different. The extent and pattern of clonal diversity within a 7-hectare native aspen woodland was also studied. Isoenzymes revealed 21 different clones within the 198 stems sampled, with some individuals spreading over 100m. These clones varied considerably in leaf flushing. The sex ratio was 3.33:1 (male: female), significantly greater than the 1.5:1 ratio normally found within Scotland. These data indicate that high clonal diversity exists within native aspen populations, and that clones differ widely in important ecological characteristics [8]. However, in another study, levels of genetic diversity appear very low in Ireland and Britain due to extensive clonality. Of the three populations analysed in England only one had some genotypic variation. In Northern Ireland, all populations were monoclonal except two. The most variable populations in Britain appear to be in Scotland at Lettoch and Speybridge [9]. Significant genetic variation between different Scottish clones in Eadha's National Aspen Clone Collection has been found [10]. Since 2013, Eadha has also identified and established a collection of 30 clones from the Lake District National Park and commenced field trials [11].

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## Beech (*Fagus sylvatica* L.)

### 2021 Status

25 registered stands, mostly selected stands located in southern England.

### Recommended Seed production approach(es)

Manage, use, and enlarge, where possible, existing registered stands.

Identify and register 10 further Seed Stands, primarily of indigenous origin, located across the full geographic and environmental ranges.

Identify and propagate 120 plus trees across Britain to establish clonal, grafted qualified Seed Orchards.

### Deliverables

Enhanced size and use of existing Seed Stands.

New Seed Stands identified and registered.

Plus trees identified and propagated to create clonal qualified Seed Orchard(s).

### Species information

#### Description

Native, large to very deciduous, shallow rooted, tree with light grey bark and dark, shiny green leaves and softly spined seed husks. Brown withered leaves may remain on the tree during winter.

#### Distribution

Widespread continuous distribution. Widely planted; it is native to S.E. England and S.E. Wales. Found up to 0-650m [1]. The species is on the edge of its north-western range in Europe.

#### Site characteristics

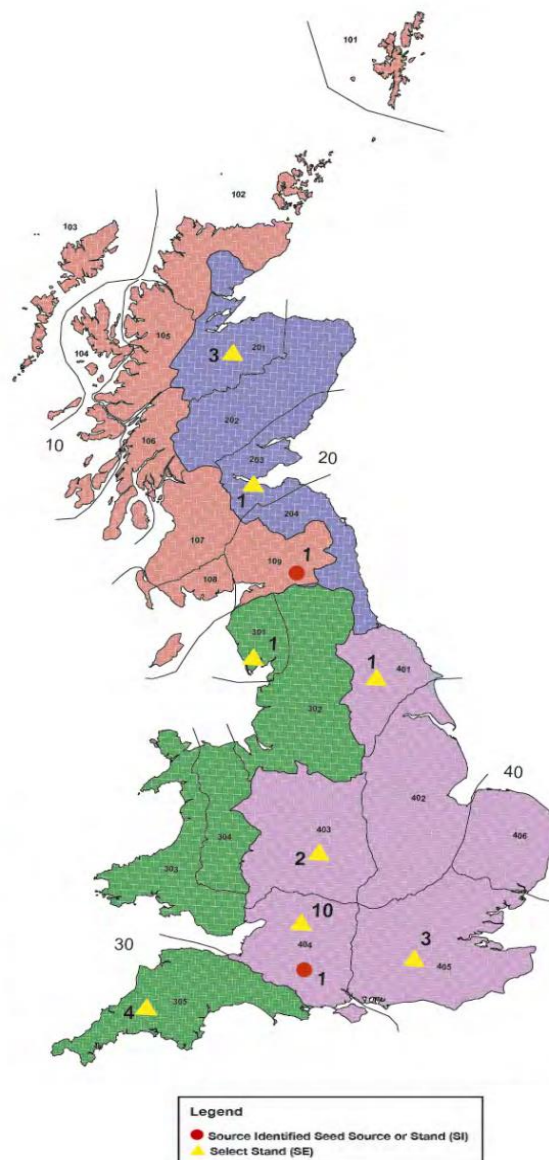
It grows well on soft soils in which the root system can easily penetrate, and its optimal growth is in humid, free draining soils situated on calcareous sites [2]. However, found on a wide variety of base-rich to acidic, free-draining soils. Highly shade tolerant so able to regenerate and survive under a full canopy. found on a wide variety of base-rich to acidic, free-draining soils. It grows in pure and mixed woodland or as standard trees or pollards in wood pasture. It is widely planted outside its native range as woodland, in avenues and as hedges [1].

## Beech

*Fagus sylvatica* (fsy)

### SUMMARY

25 Seed Stands - 116.95 hectares





### Life history

**Dispersal:** Effective geneflow [3]. Wind pollinated. Seed dispersed by animals and birds. Reproduction mode (s): Sexual, predominately outcrossing. Monoecious with separate male and female trees borne on the same tree.

**Sexual reproductive age:** 40 years onwards. Mast years every 5 to 8 years.

**Longevity:** Long lived – more than 250 years.

**Ploidy:** Diploid (2n=24).

### Threats

**Fragmentation:** No.

**Alien plantings:** Very widely planted.

**Domestication:** Very widely planted in hedges. Ornamental forms, including purple forms, frequent in gardens and parks.

**Hybridisation:** Not with other species. Potentially with alien and ornamental forms.

**Clonal reproduction:** No.

**Major pests or diseases:** No.

### Adaptive variation

European multi provenance trials (including UK provenances and trial site) revealed variation in phenology (budburst) suggesting this trait undergoes site-specific selection. South-North, East-West, and low-high elevational clines were confirmed from the analysis. Their results reinforced the need for caution in planting provenances from the south-east of Europe, expected to be suited to warmer continental conditions, in more north-westerly sites where they might be frosted [4]. Other population studies revealed local adaptations for temperature, frost, and drought [5,6,7]. Mixing of populations from divergent environmental conditions should be avoided and ecological conditions matched [1].

### Genetic diversity

Chloroplast and nuclear microsatellite markers were used for study samples from 42 sites across Great Britain. High haplotypic diversity was found near the entry point of beech into Britain. Isolation-by-distance persisted in the putative native range, together with higher levels of gene diversity in nuclear markers. However, weak regional neutral nuclear genetic structure suggested high levels of contemporary gene flow throughout the country, blurring the boundaries between native and non-native stands [7]. European studies using nuclear molecular markers show high variation within populations and little differentiation among populations [8]. However, maternally inherited DNA markers of the chloroplasts display a very high differentiation among populations [9].

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## Bird cherry (*Prunus padus* L.)

### 2021 Status

One registered Seed Stand.

### Recommended Seed production approach(es)

Source material and plant regional Source-identified Seed Stands. Consider using collections from the Millennium Seed Bank.

#### Per Seed Stand:

Number of source populations: 15.

Number of mother trees per population: 10 to 20.

Seed lot type: bulked provenance (combined seed from 10-20 mothers per population).

Target number of seedlings per population: 100.

### Deliverables

Regional Source-identified Seed Stands established.

Possibly greater number of *in-situ* Seed Stands registered.

### Species information

#### Description

Native, deciduous, shrub or small tree with attractive, heavily scented, racemes of white flowers forming black fruit. Can be invasive due to suckering habit and form thickets.

#### Distribution

Widespread with some fragmentation. Native across western and northern GB as well as parts of East Anglia. Populations typically small. It is widely planted both within, and to the south of, its native range [1]. The distinction between native and alien populations is sometimes unclear. Has the widest range in Europe of all *Prunus* species [2]. Found up to 0-650m.

#### Site characteristics

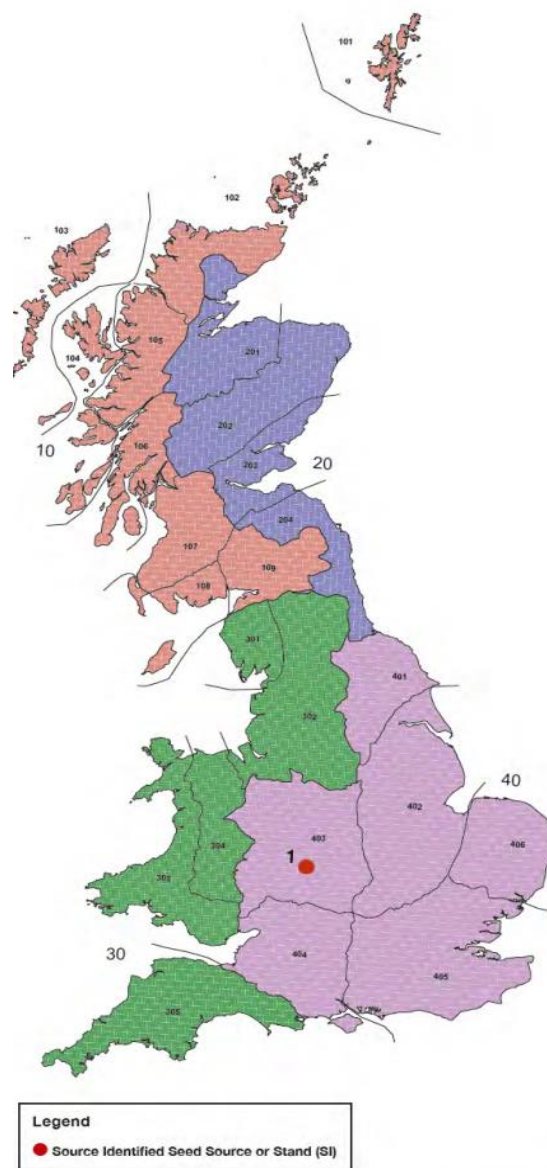
It occurs on a wide variety of soil types but is most frequent on damp calcareous or base-rich substrates and avoids very dry or very acidic conditions. Hardy and grows in various climatic conditions, including harsh winters and hot summers [3]. Found in moist woodland and scrub, streamside and shaded rocky places; also, in fen-carr in East Anglia.

## Bird cherry

*Prunus padus* (ppd)

### SUMMARY

1 Seed Stand - 0.06 hectares



## Life history

**Dispersal:** Effective geneflow [4]. Insect pollinated. Seed dispersal is primarily by birds.

**Reproduction mode (s):** Sexual- outcrossing. Monoecious, hermaphrodite flowers. Gametophytic self-incompatibility system to prevent selfing. Asexual- freely propagates clonally from basal shoots and root suckers.

**Sexual reproductive age:** 4 to 6 years onwards.

**Longevity:** Long lived, typically up to 60 years as an individual tree. Longer through clonal means.

**Ploidy:** Tetraploid, ( $2n = 32$ ).

## Threats

**Fragmentation:** Likely in parts of range.

**Alien plantings:** Widely planted.

**Domestication:** Ornamental forms widely planted in gardens and parks.

**Hybridisation:** Not with other species. Potentially with alien and ornamental forms.

**Clonal reproduction:** Very frequent, forming dense clonal clumps/thickets. Key consideration when selecting populations and sampling.

**Major pests or diseases:** No.

## Adaptive variation

**No UK data.** A common garden experiment in Belgium, using 53 genotypes propagated clonally from nine native populations and planted at two sites, studied leaf budburst, flower opening, leaf senescence and leaf fall. For all four traits, indications for natural selection were found (differentiation at the level of the populations and expansion or contraction of the growing season's length at the level of genotypes) plus indications for phenotypic plasticity (advancement or delay of all seasonal phenophases between the two plantation sites) [5]. A Swedish study reported high heritabilities for phenology traits and a positive relationship between budburst and latitude [6].

## Genetic diversity

**No UK data.** A South Korean study using AFLP markers revealed a low level of genetic diversity and large genetic differential for *P. padus* compared to that of *Prunus* species other species with a similar life history. No genetic structure was reported in relation to geographic distribution [7].

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## Blackthorn (*Prunus spinosa* L)

### 2021 Status

No registered stands/sources.

### Recommended Seed production approach(es)

Identify woodland and hedges without recent plantings and without introduced populations or potential hybrids. Make use of seed lots from Millennium Seed Bank if possible. Raise 1 year old seedlings and establish Source-identified Seed Stands. Sampling should include populations across the geographic and climatic range.

#### Per Seed Stand:

Number of source populations: At least 10.

Number of mother plants per population: 10 trees with at least 100m between them.

Seedlot type: Collect 50 seed from each of the 10 trees within a population to create a seed lot. Individually label each seed lot and maintain identity through cleaning, stratifying, and sowing.

*In-situ* Seed Stands could also be identified and registered, but care needs to be taken to avoid clonal sources with low genetic diversity. Seed viability can be variable from *in-situ* populations.

### Deliverables

Identification of, and collection from, 10 source populations. Establishment of British Source-identified Seed Stand using genetically diverse seedlings.

### Species information

#### Description

Native, deciduous, multi-stemmed, very thorny, shrub/small tree often forming dense thickets. Produced masses of white flowers in early spring before leafing. The fruit (sloes) are small, purple/black, very bitter drupes when ripe.

#### Distribution

Widespread and continuous across Britain becoming less frequent in central and northern Scotland. In many areas, native populations have been augmented by deliberate planting in hedgerows and copses. Found from 0 to 500m [1].

#### Site characteristics

Whilst able to grow on a very wide range of soil pH (except highly acid soils) and types (sandy through to heavy clays) it prefers well-drained soil. It cannot tolerate waterlogged ground nor heavy shade. It is found in open woodland, secondary woodland, scrub, poor grassland, hedgerows, screes and cliff-slopes; a prostrate form also occurs on shingle beaches.

#### Life history

**Dispersal:** Effective gene flow [2]. Insect pollinated. Seed dispersed by birds and mammals [3].

**Reproduction mode (s):** Sexual - outcrossing. monoecious, hermaphrodite flowers. Gametophytic self-incompatibility system to prevent selfing. Asexual - freely propagates clonally from root suckers.

**Sexual reproductive age:** 3 to 4 years onwards.

**Longevity:** Long lived, up to 100 years as an individual tree. Longer through persistence via vegetative root suckers.

**Ploidy:** Tetraploid, ( $2n = 32$ ).

### Threats

**Fragmentation:** Possibly in parts of range.

**Alien plantings:** Very widely planted for many centuries making it difficult to identify alien populations from native ones.

**Domestication:** Used in hedges, grown for fruit. Used as parent in rootstock breeding programmes. Some ornamental varieties exist.

Hybridisation: Able to hybridise with *P. domestica* (European plum) forming the hybrid *Prunus x fruticans*. Hybrids are fertile. Hybridization with alien populations possible.

**Clonal reproduction:** Very frequent. May be primary means of reproduction in some populations. May form large thickets. Key consideration when selecting populations and sampling.

**Major pests or diseases:** No important pathogens but it can be a natural host and potential reservoir of diseases affecting production of economically important fruits, such as apricots, plums, peaches and apples [4].

### Adaptive variation

**No UK data.** Genetic and temporal plastic variation in bud burst, bud set and flower opening responses of local versus non-local provenances of *Prunus spinosa* have been reported in study in the Flanders involving provenances from Belgium, Hungary and Spain [5].

### Genetic diversity

**Lack of UK data.** European studies have reported contrasting results in terms of genetic diversity and population differentiation. A chloroplast DNA (cpDNA) diversity study of 25 European populations including 3 British populations, found high diversity, with the majority of the total cpDNA being within populations and differentiation was low between populations. Northern European populations had lower haplotype diversity compared to southern populations [6]. A related study using cpDNA and mitochondrial DNA (mtDNA) again showed high diversity, low genetic differentiation among populations and absence of phylogeographic structure [7]. However, a study in Belgium of 8 populations using nuclear markers (AFLPS) found two populations had low diversity and were highly differentiated to the other Belgium populations, suggesting different vegetative histories. There was no clear relationship between genetic and geographic distances, nor between genetic and morphometric characteristics [8]. A German study using AFLPs and cpDNA haplotypes reveal no association between geographic and genetic distances between populations as a result of a lack of differentiation between German populations and those from southern and south-eastern Europe. However, populations with a large amount of vegetative propagation were more differentiated from other populations [9]. Population differentiation is markedly affected by the extent and frequency of clonal reproduction.

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## Dogwood (*Cornus sanguinea* L.)

### 2021 Status

No registered stands/sources.

### Recommended Seed production approach(es)

Identify primarily autochthonous sites to avoid hybrids and introduced populations especially in proximity to habitations and recent woodland plantings. Create Source-identified Seed Stands. Sampling should include populations across the entire range in different environmental conditions.

#### Per Seed Stand:

Number of source populations: 12.

Number of mother plants per population: 10-20.

Seedlot type: bulked provenance (combined seed from 10-20 mothers per population).

Target number of seedlings per population: 50.

### Deliverables

Source-identified Seed Stands established and registered.

### Species information

#### Description

Native, medium-sized, deciduous shrub with clusters of creamy-white, four petalled flowers and small purple-black berries. Young twigs are bright red and leaves turn crimson in autumn.

#### Distribution

Widespread and continuous in southern Britain except for SW, becoming scarce/absent to west and north. Primarily a lowland species.

#### Site characteristics

It prefers consistently moist, well-drained soils, but it grows in a wide range of soils, from dry to humid with different pH levels [1]. Thrives in full sun, some tolerance of shade. Locally frequent in woodland, scrub, hedgerows and shelterbelts on limestone soils or base-rich clays, and sometimes dominant in hedges and scrub on chalk [2]. Very frequently planted as an ornamental in landscaping schemes, parks and gardens.

#### Life history

**Dispersal:** Effective gene flow [3]. Insect pollinated. Seed dispersed by birds.

**Reproduction mode (s):** Sexual - predominately outcrossing although selfing is possible. monoecious, hermaphrodite flowers. Able to adapt its reproductive behaviour to habitat conditions, reproducing by seeds, dispersed principally by birds, or limiting the flower blossom and promoting a vigorous clonal growth when in heavy shade [2].

**Sexual reproductive age:** 3-5+ years.

**Longevity:** Long lived, up to 100 years as an individual plant. Longer through vegetative means.

**Ploidy:** Diploid ( $2n = 22$ ).

## Threats

**Fragmentation:** Potentially fragmented towards limited of range.

**Alien plantings:** Very widely planted in rural and urban settings.

**Domestication:** Many ornamental forms and varieties developed.

**Hybridisation:** Potentially with alien and ornamental forms.

**Clonal reproduction:** Yes, via advantageous rooting and layering. \*Key consideration when selecting populations and sampling depending on site conditions.

**Major pests or diseases:** No.

## Adaptive variation

**No UK data.** A study in Denmark found significant genetic variation in spring flushing within and among populations. A high level of differentiation was located among populations [4]. The authors proposed that the variation among populations is likely the result of natural selection and neutral selection and neutral processes simultaneously.

## Genetic diversity

**No UK data.** A European study of 86 populations of dogwood (none from UK) using chloroplast DNA markers reported low level variation with one haplotype strongly dominating the range [5]. There was no geographic pattern revealed by other haplotype groups. Microsatellite markers have been developed and characterised on a small set of German dogwood samples [6].

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## Elder (*Sambucus nigra* L.)

### 2021 Status

No registered stands.

### Recommended Seed production approach(es)

Identify autochthonous seed collection sites, avoiding hybrids and introduced populations especially in proximity to habitations and recent woodland plantings. Make use of Millennium Seed Bank data and resources if possible. Create Source-identified Seed Stands. Sampling should include populations from across the range in different environmental conditions and avoiding clonal populations.

#### Per Seed Stand:

Number of source populations: 12.

Number of mother plants per population: 20-30.

Seedlot type: bulked provenance (combined seed from 20-30 mothers per population).

Target number of seedlings per population: 50.

In addition, register *in-situ* populations as Seed Stands.

### Deliverables

New Source-identified Seed Stands established.

*In-situ* Seed Stands registered.

### Species information

#### Description

Native, medium-sized, deciduous, vigorous, sprawling shrub sometimes small tree, with clusters of creamy-white and small black berries.

#### Distribution

Widespread and continuous in Britain except parts of northern Scotland. British reported altitude limit is 470m [1].

#### Site characteristics

Prefers fertile soils but able to grow on a wide range on soil types and pH's. As it is relatively light demanding, it is predominantly a shrub of open areas and woodland edges [2]. Also often associated with disturbed, base-rich and nitrogen-rich soils, eutrophic and phosphate-rich soils. Highly resistant to pollution. Found in a wide range of habitats including woodland, hedgerows, grassland, scrub, waste ground, roadsides and railway banks [3]. Frequently planted as an ornamental in landscaping schemes, parks and gardens.

#### Life history

**Dispersal:** Effective geneflow [4]. Insect pollinated. Seed dispersed by birds and mammals.

**Reproduction mode (s):** Sexual - outcrossing, Selfing possible, however flower clusters pollinated with pollen from the same plant set few viable seeds compared with those

pollinated with pollen from genetically different individuals [5]. monoecious, hermaphrodite flowers. Asexually via root suckering and layering.

**Sexual reproductive age:** 3+ years.

**Longevity:** Long lived, up to 100 years as an individual plant. Longer through vegetative means.

**Ploidy:** Diploid ( $2n = 36$ ).

### Threats

**Fragmentation:** Potentially in parts of range.

**Alien plantings:** Very widely planted in rural and urban settings.

**Domestication:** Ornamental forms and varieties developed. A breeding programme in Kent has developed new cultivars of *S. nigra* with different plant size, form, leaf shape and colour, and flower colour [6,7]. These are now very widely planted.

**Hybridisation:** Potentially with alien and ornamental forms. Hybridisation with *S. racemosa* (Red elderberry) is very rare [2] and the offspring are sterile.

**Clonal reproduction:** Yes, via advantageous rooting and layering.

**Major pests or diseases:** No.

### Adaptive variation

**No UK data.**

### Genetic diversity

**No UK data.** Microsatellites have been developed [8]. They have been used to determine interspecific hybrid structures in *Sambucus* breeding programme in Slovakia. Interspecific hybrids were created as phenotypic and genotypic variations within the genus *Sambucus* are limited [9].

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## Field maple (*Acer campestre* L.)

### 2021 Status

One registered stand.

### Recommended Seed production approach(es)

Identify and register 10 Seed Stands outside of Region 40 ideally of known indigenous origin.

Create a grafted Seed Orchard for region 30.

#### Per grafted Seed Orchard:

Number of source populations: At least 15 (in Region 30).

Number of mother plants per population: At least 4.

Material to collect: Grafting material.

### Deliverables

10 *in-situ* Seed Stands identified and registered.

Grafted seed orchard for Region 30.

### Species information

#### Description

Native, medium-sized deciduous tree with colourfully autumn foliage and winged, double samaras. Typically, multi-stemmed and heavily branched but form standard trees. Coppices well.

#### Distribution

Widespread, continuous distribution in England and Wales. It has also been very extensively planted both within and beyond its native range, and these introductions tend to blur the boundary of its native range [1]. Found up to 380m. The species is on the edge of its north-western range in Europe.

#### Site characteristics

Prefers warm sites but able to tolerate extreme cold and heat. Favours calcareous soils, but also grows well on heavy clay providing it is waterlogged. It is extremely shade tolerant during the first decade of growth but more light demanding in seed-bearing years. Found in native woodland, scrub and old hedgerows. It is also widespread as a planted tree in amenity areas, on farmland, along roads and in hedgerows and coppice.

#### Life history

**Dispersal:** Limited gene flow [2]. Primarily insect pollinated, part wind. Seed dispersed by wind.

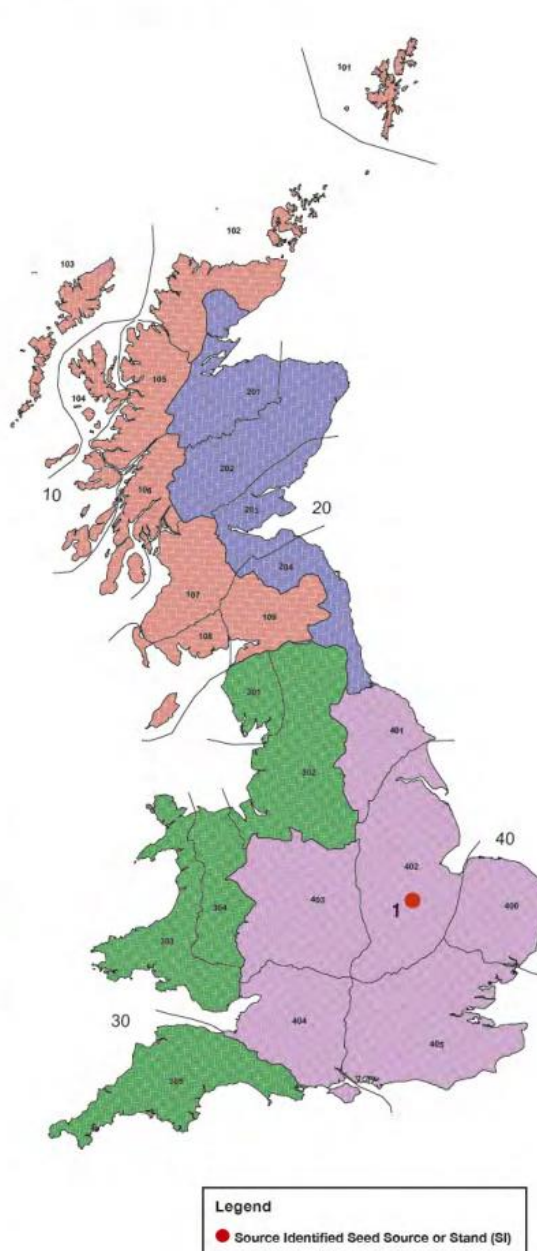
**Reproduction mode (s):** Sexual - outcrossing, partial self-compatibility. Monoecious, hermaphrodite flowers, however owing to the reduction of one of the sexes they are

## Field maple

*Acer campestre* (aca)

### SUMMARY

1 Seed Stand - 9.40 hectares



functionally unisexual. Dominantly male or female individuals are often observed [3]. It fruits erratically, sometimes producing only male flowers following a year of prolific fruiting [1].

**Sexual reproductive age:** 5 to 20 years onwards.

**Longevity:** Long lived, especially as coppice - 100 to 500 years.

**Ploidy:** Diploid ( $2n = 26$ ).

### Threats

**Fragmentation:** Likely in parts of range, especially western and northern edges.

**Alien plantings:** Very widely planted.

**Domestication:** Very widely planted in hedges. Ornamental forms frequent in gardens and parks.

**Hybridisation:** Not with other species. Potentially with alien and ornamental forms.

Clonal reproduction: No.

**Major pests or diseases:** *Cryptostroma corticale*, an introduced fungal pathogen which causes Sooty Bark Disease in Acer species, resulting in serious tree damage or death after hot and dry summers [4]. Note that the spores are hyper-allergenic to humans; they can cause severe asthma and hypersensitivity pneumonitis.

### Adaptive variation

**No UK data.** There is evidence of phenotypic plasticity and wide ecological range for the species in Europe [3].

### Genetic diversity

**No UK data.** Genetic differentiation is presumed from the high morphological polymorphism and its very wide ecological range. May have higher between-population variation compared with other widely distributed species due to life history traits [4]. A study in Poland using nuclear SSRs found that field maple located closer to the northern margin of the natural range were characterised by lower genetic variation and higher divergence rates. It demonstrated that the species abundance decreased towards range limit concurs with sharp genetic patterns in *A. campestre*. It also demonstrated that the latitudinal genetic variation was observed even at a local spatial scale. They speculated that this may be mostly due to high fragmentation and low dispersal capabilities [5]. In Bosnia and Herzegovina, 10 nuclear SSR were used to study 25 populations. Genetic differentiation within this region was very weak. However, significant isolation by distance was revealed, along with isolation by environment related to temperature. They suggest phenological isolation as the explanation of isolation by environment [6].

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## Common hawthorn (*Crataegus monogyna* Jacq.)

### 2021 Status

Three registered seed sources.

### Recommended seed production approach(es)

Identify autochthonous sites (ideally without Midland thorn), to avoid hybrids and introduced populations especially in proximity to habitations. Create regional Source-identified Seed Stands.

#### Per regional Seed Stand:

Number of source populations: 10.

Number of mother trees per population: 20-30.

Seedlot type: bulked provenance (combined seed from 20-30 mothers per population).

Target number of seedlings per population: 100.

Register source populations as *in-situ* Seed Stands.

### Deliverables

Regional Source-identified Seed Stands established.

*In-situ* Seed Stands registered.

### Species information

#### Description

Native, small, thorny, deciduous tree with attractive, clusters usually white sometimes slightly pink flowers. The dark red berries are produced in large quantities.

#### Distribution

Widespread, continuous distribution across Britain except in upland areas where populations might be fragmented. Widely planted as a hedging plant for many centuries, and the limits of its native range are unclear. In N. Scotland it is often confined to the vicinity of habitation, and in some areas is certainly introduced. Found up to 610m [1].

#### Site characteristics

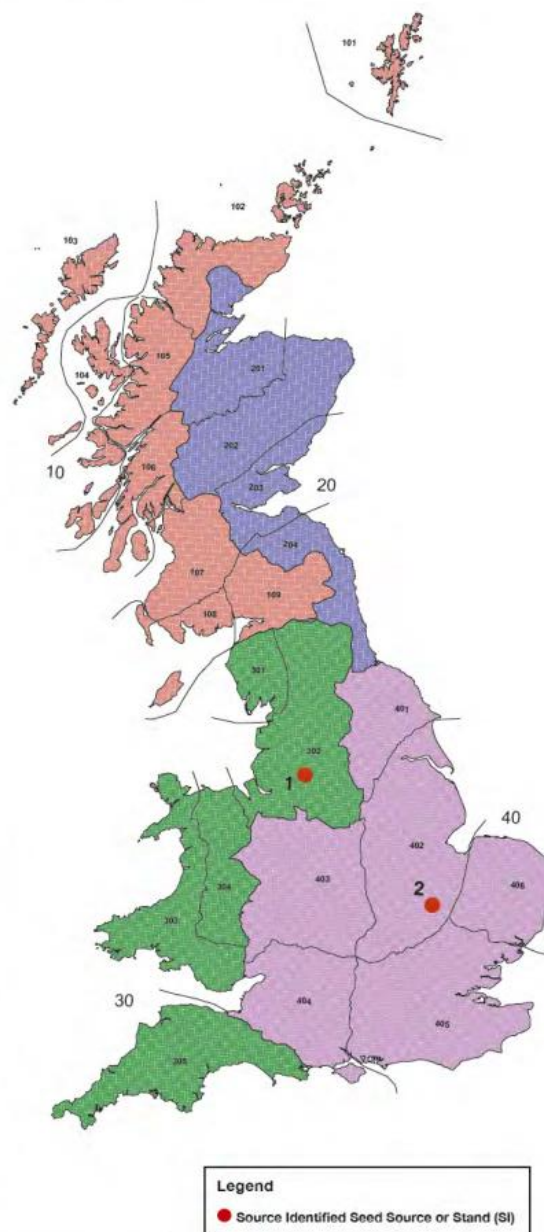
Hardy and grows in various climatic conditions, prefers open or partial shade. It is tolerant to a very wide variety of soils providing they are free draining. Found in hedgerows, scrub and wood-borders, and as an understorey in open woodland. It can persist as scattered bushes in grazed sites, spreading rapidly when grazing declines or ceases [1].

## Common hawthorn

*Crataegus monogyna* (cmo)

### SUMMARY

3 Seed Stands - 36.90 hectares



## Life history

**Dispersal:** Effective geneflow [2]. Insect pollinated. Seed dispersal by birds and animals.

**Reproduction mode (s):** Sexual - outcrossing. monoecious, hermaphrodite flowers. Gametophytic self-incompatibility system to prevent selfing.

**Sexual reproductive age:** 3 to 5 years, sometimes earlier.

**Longevity:** Long lived - 200+ years.

**Ploidy:** Diploid ( $2n=34$ ).

## Threats

**Fragmentation:** Potentially in upland areas.

**Alien plantings:** Very widely planted.

**Domestication:** Very widely planted in hedges. Ornamental forms and varieties developed and planted in gardens and parks.

**Hybridisation:** Hybridisation and introgression with *C. laevigata* (Midland thorn) is widespread in southern parts of range. Hybrids with non-native *C. heterophylla* reported at three locations in GB.

**Clonal reproduction:** Very infrequently.

**Major pests or diseases:** Major pests or diseases.

## Adaptive variation

Hawthorn exhibits phenotypic plasticity in leaf morphology, budburst and flowering [3,4]. Evidence of local adaptations have been found in UK hedgerows, with the most locally obtained provenance having the latest bud-burst, exhibited the least severe symptoms of mildew and was the most thorny provenance [5]. Cultivars are commonly planted in hedges and along roadsides or for ornamental purposes. The origin of this stock is not always known, so genetic exchange with the natural populations may lead to introgression and thus genotypes that are more adapted than the local genotypes in a changed environment [6].

## Genetic diversity

**Very limited UK data.** A European study of 21 populations including three for UK undertaken with cpDNA markers, found a low level of genetic diversity as well as moderate genetic differentiation among the populations [7]. Similar results were found in a study of Italian populations [8].

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## Hazel (*Corylus avellana* L.)

### 2021 Status

Very limited registered stands/sources with concerns raised about trueness to type.

### Recommended seed production approach

Identify autochthonous sites to avoid hybrids, introduced populations especially in proximity to habitations, nut orchards and recent woodland plantings. Use Millennium Seed Bank resources if possible. Create Source-identified Seed Stands. Sampling should include populations from across the range in different environmental conditions and from some smaller woodland. At each site, sampled trees should be mature, well-established plants and physically separated by at least 100m.

#### Per Seed Stand:

Number of source populations/sites: 10 (minimum).  
Number of mother trees per population/site: Up to 20, select and collect propagating material.  
Target number of replicates per tree: 5, grown on as planting material.

Autochthonous *in-situ* sites may be registered as Seed Stands, but these are unlikely to be productive due to squirrel predation.

### Deliverables

True-to-type wild hazel identified and propagated to create Seed Stands.

Register *in-situ* Seed Stands.

### Species information

#### Description

Native, deciduous, multi-stemmed, common shrub/small tree often coppiced and forming a spreading canopy. Produces long, yellow male catkins and tiny red female flowers in early spring. The edible fruit is a nut, grouped in clusters of one to four together. Each nut is held in a short leafy involucre (husk) which encloses about half of the nut. The nut is roughly spherical, up to 2cm long, yellow-brown with a pale scar at the base [1].

#### Distribution

Widespread and continuous across Britain. In many areas, native populations have been augmented by plantings. Found from 0 to 640m [2].

#### Site characteristics

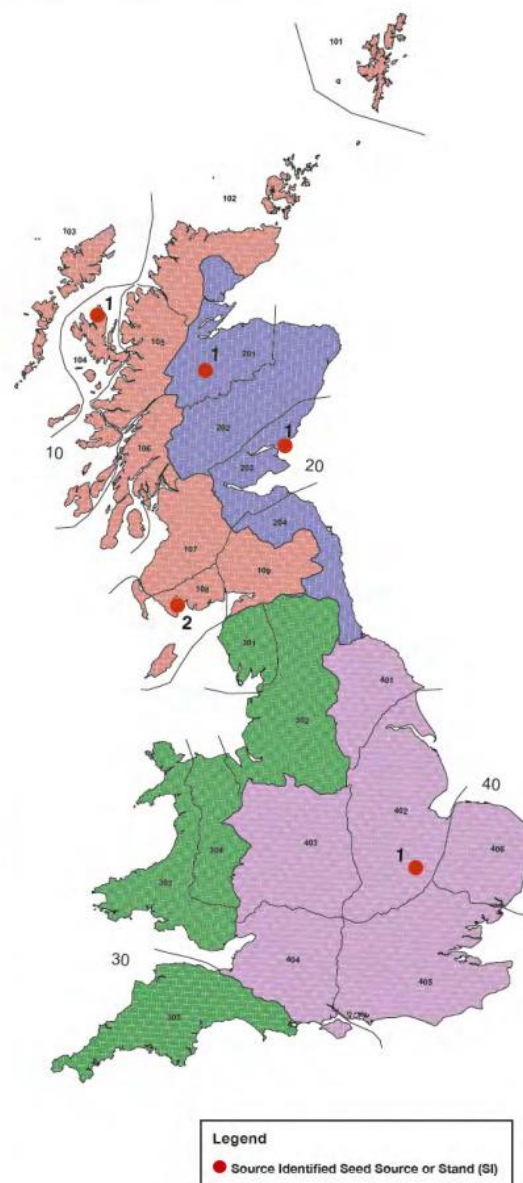
Able to grow on dry or damp, calcareous to mildly acidic soils, but favouring moist, base-rich conditions. It can grow in both full sun and in shade, and able to resist cold

## Hazel

*Corylus avellana* (cav)

### SUMMARY

6 Seed Stands - 193.66 hectares



temperatures and frost [1]. It is native in the understorey of many woods especially deciduous woodland, in scrub, hedgerows, on river banks, limestone pavement, cliffs and gullies [2]. Main canopy species in Atlantic hazel woodland. Widely planted in copses and hedgerows. Intolerant of heavy browsing.

### Life history

**Dispersal:** Effective gene flow [3]. Wind pollinated. Seed dispersed by birds and mammals [1].

**Reproduction mode (s):** Sexual - outcrossing. monoecious, with separate male and female flowers. Sporophytic self-incompatibility system, controlled by a single locus with multiple alleles, to prevent selfing [4]. Asexual - clonally via layering and basal shoots (suckers).

**Sexual reproductive age:** 10+ years.

**Longevity:** 80+ years, longer if trees are coppiced.

**Ploidy:** Ploidy.

### Threats

**Fragmentation:** Possibly in parts of range.

**Alien plantings:** Very widely planted for many centuries making it difficult to identify alien and plants derived from cultivated 'cobnut' populations from native ones.

**Domestication:** Widely grown for fruit especially in SE England. Used in hedges and amenity plantings. Many fruit varieties and some ornamental varieties exist.

**Hybridisation:** Able to hybridise with the closely related, introduced species *C. maxima* (*Filbert*). Also able to hybridise with a wide range of other *Corylus* species including *C. colurna* [5]. Hybridization with alien populations is possible.

**Clonal reproduction:** Infrequent - layering of adventitious shoots or branches rather than via underground root suckers.

**Major pests or diseases:** Not yet in UK. *Pseudomonas avellana*, responsible for the bacterial canker and decline of hazelnut and *Anisogramma anomala* (Eastern Filbert Blight) that causes canker are concerns [6].

### Adaptive variation

**No UK data.** In a Danish study, spring phenology (bud burst) was found to be correlated with climatic variables. There was significant population differentiation supporting some past natural selection in favour of local adaptation [7]. Hazel is reported to have high phenotypic plasticity in its responsiveness to light variations, with a greater plasticity of morphological traits than of physiological and anatomical traits [8].

### Genetic diversity

**Very limited GB data.** An Irish study of 29 populations using nuclear microsatellites found that hazel populations exhibit high levels of genetic diversity along with low levels of population differentiation, suggesting extensive gene flow. Four out of the five examples of fine-scale genetic structuring observed, occurred in some of the smallest woodlands analysed [6]. A study of 200 individuals from cultivated and wild hazelnut trees collected in the Black Sea region in Turkey, along with related *Corylus* species and specimens from the United Kingdom, Georgia, and Italy conducted with double digest restriction enzyme-associated DNA sequencing (ddRAD-seq) revealed that cultivated hazelnuts showed

elevated heterozygosity (greater diversity) compared to wild individuals [9]. Genetic variation at two types of chloroplast DNA markers, polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP) and microsatellites, was assessed in 26 natural hazel populations distributed across the range of *C. avellana* including three British populations. Very little variation was detected overall but the microsatellite markers, which have the highest levels of variation, show a clear geographical structure that divides Europe into two areas: (i) Italy and the Balkans, and (ii) the rest of Europe (including GB). The two main haplotypes identified with both PCR-RFLP and sequencing, were found in *C. avellana* and in other European *Corylus* species and cultivars, suggesting a history of past hybridization [10]. Other studies have also found differentiation between cultivars and/or wild types and by geographical origin [11-13].

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## Holly (*Ilex aquifolium* L.)

### 2021 Status

No registered stands/sources.

### Recommended seed production approach(es)

Identify 12 diverse, native Seed Stands for registration by agreeable landowners. Millennium Seed Bank data will help with this.

Create regional seedling Source-identified Seed Stands. Identify autochthonous sites to avoid hybrids and introduced populations especially in proximity to habitations. Consider using collections from the Millennium Seed Bank if possible.

#### Per regional Seed Stand:

Number of source populations/sites: 15.

Number of mother trees per population/site: 20.

Seedlot type: bulked provenance (combined seed from 20 mothers per population).

Target number of seedlings per population: 100.

### Deliverables

Twelve registered *in-situ* Seed Stands.

Regional Seed Stands established.

### Species information

#### Description

Native, small to medium-sized evergreen tree with dark green, leathery, prickly leaves, white blossom and bright red berries.

#### Distribution

Widespread and continuous; very widely planted and frequently naturalised. It has been increasing naturally in many woods in recent decades, probably partly because of milder winters. Reported as becoming a nuisance in British woods, where it is forming “thickets” invading heathland and old wood forests [1]. Grows up to 600m.

#### Site characteristics

Prefers well-drained, acidic soils but able to grow in most soils, including peat, chalk, gravels, sand and shales, so long as they are not water-logged. It thrives in shade to semi-shade conditions. It tolerates maritime exposure as well as air pollution [2]. Found in deciduous woodlands, especially those on acidic soils in which *Fagus* and *Quercus* predominate; often a frequent or locally dominant undershrub but rarely dominating the canopy. Also found in wood-pasture, scrub and hedgerows, and on ledges of acidic cliffs, and is often planted in amenity areas and parkland [3].

#### Life history

**Dispersal:** Effective geneflow [4]. Insect pollinated. Seed dispersed predominately by birds (and mammals). Bird dispersal has been reported to be non-random and associated with habitat type [5].

**Reproduction mode (s):** Sexual - outcrossing. Dioecious.

**Sexual reproductive age:** 5+ years.

**Longevity:** Long lived, up to 200 years.

**Ploidy:** Diploid ( $2n = 40$ ).

### Threats

**Fragmentation:** Plantings obscure native range.

**Alien plantings:** Very widely planted in natural and domestic settings.

**Domestication:** Many ornamental forms and varieties developed.

**Hybridisation:** Potentially with alien and ornamental forms. Hybridisation with the introduced *I. perado* (*I. x altaclerensis*) is reported. The hybrid is fully fertile and bird- and self-sown plants are often recorded and seedling regeneration [6].

**Clonal reproduction:** Very little naturally. Ornamental forms, especially female trees, frequently vegetatively propagated.

**Major pests or diseases:** No.

### Adaptive variation

**No UK data.** A study in France found significant among population variations for height growth but not for phenological traits. Population growth followed an altitudinal trend with a linear decline in height between the lowest and highest populations [7].

### Genetic diversity

**Limited UK data.** A study in Denmark of wild populations and cultivars using SSR and AFLP markers, found no clear large-scale geographical patterns nor distinction between historic 'wild' and cultivar genotypes. The variation among and within cultivars was higher than that found in wild samples. The lack of genetic differentiation between the wild and cultivated forms indicates that naturalisation is correlated with range expansion in this species. Greater frost hardiness, fruit production and bird dispersal of the cultivars contributes to range shift [8]. A European study using chloroplast markers found high differentiation between populations and evidence of phylogeographical structure. The two most common European haplotypes were found in two British populations but with divergent genetic lineages representing different re-colonisation routes from European refugia to Britain [9].

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## Hornbeam (*Carpinus betulus* L.)

### 2021 Status

No registered stands.

### Recommended seed production approach(es)

Identify, register, and manage new hornbeam *in-situ* Seed Stands across its entire distribution range using FTT report [9] as a key resource.

Create clonal Seed Orchards. Identify at least 100 plus trees, collect graft wood and create clonal Seed Orchards.

#### Per clonal Seed Orchard:

Number of genotypes: At least 50.

Number of replicates per genotype: 10.

Material to collect: Grafting material.

Total number of trees:  $50 \times 10 = 500$ .

### Deliverables

Registration of native hornbeam *in-situ* Seed Stands.

Creation of clonal Seed Orchard.

### Species information

#### Description

Native, small to large sized, deciduous tree with steel grey, rippling bark, often retaining withered brown leaves in winter. Seed borne are in clusters of winged, paired cupules. Typically grown as coppice in southern Britain, sometimes pollarded and occasionally as high forest.

#### Distribution

Confined as a native to SE England [1] with largest populations concentrated in ancient woodland east and north of London, and in the Weald of Kent & Sussex. Christy (1924) also provided a convincing argument for its native status in southwest Britain, with possibly also a native outpost around the Severn basin [2]. Extensively planted, especially in England, in woodlands, on roadsides, in amenity areas and for hedging. Lowland as a native, but to 380 m as an alien [1].

#### Site characteristics

Very hardy species and even found in frost hollows. It favours deep moist and well-drained soils from sub-acid to calcareous, although it can tolerate wet heavy clay to light dry sandy soils, but never acid. Very shade tolerant but grows well in partial or full sun [3]. Found as native in both pure and mixed woodland on base-poor sandy or loamy clays, or clay-with-flints. Within its native range, coppiced plants are often the dominant member of the shrub layer in *Quercus* woods.

#### Life history

**Dispersal:** Effective geneflow [4]. Wind pollinated. Seed dispersed by wind and potentially by animals.

**Reproduction mode (s):** "Sexual outcrossing. Monoecious: flowers are unisexual, borne in pendulous catkins, male flowers in advance of female flowers. Occasional asexual vegetative reproduction by 'root suckers'. However, these are rarely (if ever) true roots but are rather the result of natural self-layering of lower branches especially in coppiced trees (branches arching downwards to contact the soil at which point they root) [5].

**Sexual reproductive age:** 20+ years.

**Longevity:** Long lived - up to 500 years.

**Ploidy:** Octoploid (2n=64).

### Threats

**Fragmentation:** Potential fragmentation of range especially to north and west.

**Alien plantings:** Widely planted.

**Domestication:** Widely planted in hedges. Ornamental forms planted in gardens and parks.

**Hybridisation:** Not with other species. Potentially with alien and ornamental forms.

**Clonal reproduction:** Unlikely unless through layering.

**Major pests or diseases:** No.

### Adaptive variation

No UK data or other data found.

### Genetic diversity

No UK data. At a European level, cpDNA variation showed high structure and diversity concentrated in SE Europe [6,7]. However, study using AFLPs, revealed high within-population diversity and little (but significant) genetic differentiation were detected at Flemish and European scales [8].

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## Juniper (Juniperus communis L.)

### 2021 Status

No registered stands/sources.

### Recommended seed production approach(es)

For both sub species *communis* and *nana* identify diverse, native Seed Stands for registration and management. Seed Orchards are not recommended due to slow maturation time and low seed production.

Develop appropriate plant health procedures to avoid spread of *Phytophthora austrocedri*.

### Deliverables

*In-situ* Seed Stands identified and registered for the two main sub species.

## Species information

### Description

Native, evergreen conifer forming shrub or small tree. Very prickly, small needle-like leaves and berry-like cones which are fleshy, purple/black and aromatic when ripe. Three sub species in the UK – sub species *communis* varies from a spreading shrub to an erect tree while ssp. *nana* is a small procumbent shrub. The third subspecies, *hemisphaerica*, has two small populations on maritime cliffs in the UK [1], is not considered further here.

### Distribution

Wide, discontinuous and fragmented distribution. *J. communis* ssp. *communis* is characteristic of the lowlands, including the distinctive communities on chalk in southern England, but extends onto suitable sites in northern England and Scotland. Found up to 975m. *J. communis* ssp. *nana* has a smaller range, restricted to the uplands of North Wales, Cumbria and Scotland plus a number of populations. As an occasional component of montane (subalpine) scrub in the northern corries of Cairn Gorm, Scotland [1]. Found up to 950m.

### Site characteristics

*J. communis* ssp. *communis* is characteristic of free draining, calcareous soils in southern England, various soils in the Scottish Highlands. *J. communis* ssp. *nana* is restricted to well-drained, acid bogs and, more usually, rocky outcrops, generally as a minor component of upland heaths and montane scrub. Both subspecies are light demanding, drought and frost tolerant, intolerant of waterlogging and sensitive to fire.

### Life history

**Dispersal:** Effective gene flow [2]. Wind pollinated. Seed dispersed predominately by birds (and mammals).

**Reproduction mode (s):** Sexual - outcrossing. Dioecious, occasionally monoecious.

**Sexual reproductive age:** 6+ years.

**Longevity:** Long lived, up to 200 years.

**Ploidy:** Diploid ( $2n = 22$ ).

### Threats

**Fragmentation:** Extensive. Excessive grazing and burning has reduced populations sizes and ranges.

**Alien plantings:** Very widely planted in natural and domestic settings.

**Domestication:** Many ornamental forms and varieties developed.

**Hybridisation:** Potentially between alien and domestic populations. Frequent intermediate forms between the two sub species *communis* and *nana*.

**Clonal reproduction:** Occasionally through branches contacting the ground and layering.

**Major pests or diseases:** *Phytophthora austrocedri*, an aggressive, fungal-like pathogen [3].

### Adaptive variation

**No UK data.** Phenotypic plasticity occurs across the range.

### Genetic diversity

High genetic diversity and differentiation in Britain has generally been found. A study using AFLPS, revealed that all populations assessed showed high levels of genetic variation although there was clear structuring between populations demonstrating limited gene flow. English, Welsh and northern Scottish populations appeared genetically discrete [4]. In Ireland, significant genetic differentiation of populations has been found using both chloroplast and nuclear DNA markers, indicating restricted gene flow, particularly over larger geographic scales [5]. A study using RAPD markers showed that populations in the Scottish Borders had little between-population diversity with 93% of RAPD variation being within populations and only 7% between populations suggesting a large gene pool with substantial gene flow between these populations and therefore low genetic isolation [6]. A Dutch study of heathland populations found that differentiation amongst populations was small and gene flow high [7]. In Polish pharmaceutical study, no difference between the two subspecies on the basis of chloroplast DNA or monoterpene content has been found [8].

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## Norway maple (*Acer platanoides* L.)

### 2021 Status

No registered stands.

### Recommended seed production approach(es)

Identify and register six mature Seed Stands, located across geographic and environmental range occupied by the species in Britain but isolated from cultivated forms.

Assess whether existing provenance trials could be used as Seed Stands or Seed Orchards.

### Deliverables

Six *in-situ* Seed Stands identified and registered.

Diverse Seed Stands or Seed Orchards created from provenance trials.

## Species information

### Description

Non-native, large deciduous tree with spreading canopy. Leaves have five lobes which are sharply pointed and striking autumn colours. The flowers are bright green and form clusters. Seed is brightly coloured (green through to scarlet), winged and arranged in pairs.

### Distribution

Widespread and continuous distribution for much of Britain. It was in cultivation in Britain by 1683 and has been known from the wild since at least 1905 [1]. It is widely planted as an ornamental tree, often as one of its cultivars. Seeds freely and frequently naturalised. Generally lowland but reaching 340m.

### Site characteristics

Able to grow well across a wide range of soil conditions, shade, drought, and pollution. However, it thrives best in deep, fertile, moist soils, which are adequately drained and with a sub-acid pH [2]. Exposure and strong calcareous soils are well tolerated. Found in woodland, hedgerows, amenity areas, gardens, parks and along roads. Becoming naturalised in secondary woodland, rough grassland, scrub, and urban waste land [1].

### Life history

**Dispersal:** Effective geneflow. Insect pollinated. Seed dispersed predominately by wind.

**Reproduction mode (s):** Sexual - predominately outcrossing. Typically monoecious, hermaphrodite flowers but dioecious flowering reported [2,3].

**Sexual reproductive age:** 10+ years.

**Longevity:** Long lived, 250 years.

**Ploidy:** Diploid ( $2n = 26$ ) [4].

### Threats

**Fragmentation:** Introduced species so no natural range.

**Alien plantings:** Very widely planted in natural and domestic settings.

**Domestication:** Many wild ornamental forms and varieties developed.

**Hybridisation:** Not with native species. Potentially with ornamental varieties.



Clonal reproduction: No.

**Major pests or diseases:** *Cryptostroma corticale* (Sooty Bark Disease), a fungal pathogen, can with serious damage after hot and dry summers. *Verticillium* wilt can be problematic in seedlings.

### Adaptive variation

A provenance trial, at two sites in Bedfordshire, to investigate the early growth and form of 10 provenances of Norway maple (*Acer platanoides*) from six countries, found that provenances from Germany, the Netherlands, Denmark and Yugoslavia performed well. A Hungarian provenance was intermediate in performance and the Russian provenance was relatively poor [5]. A nursery study in Sweden found significant population differentiation for growth and phenology traits [6]. Cold hardiness was studied in three populations from Sweden, Denmark and Germany. The variation in cold hardiness among populations was structured as a moderate latitudinal cline, with the northern population (Sweden) cold acclimating earlier and/or faster than the other populations [7]. A study of *A. platanoides* seed collected along a 2200km long latitudinal gradient from Italy to Norway indicated that the seed mass seed was negatively influenced by increasing temperatures, and that seed viability was related to seed mass, with larger seeds having higher viability [8].

### Genetic diversity

**No UK data.** The genetic diversity and differentiation of Latvian 21 *A. platanoides* populations representing a range of ecological conditions, with differing levels of anthropogenic impact was analysed with eight microsatellite markers. No significant relationship between genetic and geo-graphical distance was found. Moderate levels of genetic diversity and moderate differentiated were found [9]. Similar to results for an isoenzyme study of 12 Swedish and Finnish populations of *Acer platanoides* [10].

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## Service tree (*Sorbus torminalis* L. (Crantz)/ *Torminalis glaberrima* (Gand.))

### 2021 Status

No registered stands.

### Recommended seed production approach(es)

Identify and register 10 diverse, native stands with at least 20 genetically distinct, mature individuals at each site. Enhance management to improve light to crown.

Create a clonal Seed Orchard or clonal Source-identified Seed Stand.

#### Per Seed Orchard/Seed Stand:

Number of source populations: At least 20.

Number of mother plants per population: At least two.

Material to collect: Grafting material.

### Deliverables

Registration and management of *in-situ* native wild service tree Seed Stands.

Creation of clonal Seed Orchard or clonal Source-identified Seed Stand.

### Species information

#### Description

Native, uncommon, typically medium-size, deciduous tree but able to reach 33m in height. Leaves are lobed and pointed, similar to maple, and turn a rich, coppery red in autumn. Clusters of white flowers and red/yellow turning to brown pome fruit.

#### Distribution

Widespread but scattered throughout the lowlands of Wales and England, especially in the Weald and the Wye Valley, continuing northwards to Northumberland and south Cumbria, although its natural northern limit is probably around Morecambe Bay. It is largely absent from Scotland except as an uncommon introduction [1]. The northerly distribution is primarily limited by cool summers that reduce successful seed production [2].

#### Site characteristics

The most shade tolerant of genus *Sorbus*, but it still relies on more open and well-lit situations to persist and for mature trees to develop. Only moderately frost and cold resistant [3]. Favours deep fertile soils, but can tolerate a wide range of soil conditions, from limestone, chalky, superficial, dry soils to temporarily waterlogged soils including clays. Strongly associated with woodland, especially ancient woodland sites [1] where it may also form small stands through root-layering. Also found in hedges and scrub. Planted trees occur in parks, plantations, and urban settings.

#### Life history

**Dispersal:** Effective gene flow [4]. Insect pollinated. Seed dispersal is primarily by birds and small mammals.

**Reproduction mode (s):** Sexual - outcrossing. monoecious, hermaphrodite flowers. Gametophytic self-incompatibility system [5]. Asexual - freely propagates clonally from root suckers to colonize disturbed areas and to survive the competition from other species [3].

**Sexual reproductive age:** 10 years onwards.

**Longevity:** 200+ years.

**Ploidy:** Diploid ( $2n=34$ ) [1].

### Threats

**Fragmentation:** Likely in parts of range.

**Alien plantings:** Widely planted.

**Domestication:** Ornamental forms widely planted in gardens and parks.

**Hybridisation:** Able to hybridize with at least two other species of *Sorbus*: whitebeam (*Sorbus aria*) and mountain ash (*Sorbus aucuparia*). Hybridization with whitebeam commonly occurs, especially where the natural ranges of these species overlap. Most of these hybrids are triploid ( $3n=51$ ) and a few (mainly *Sorbus latifolia*) are tetraploid ( $4n=78$ ). Hybrids reproduce mainly by apomixes [4].

**Clonal reproduction:** Very frequent, forming clonal groups. Key consideration when selecting populations and sampling.

**Major pests or diseases:** No.

### Adaptive variation

No data. Three replicated trials using 9 seed lots (3 English, 4 French, 1 German and 1 Italian) were planted out winter 2019/20 at three English sites and are being monitored for growth and performance [6].

### Genetic diversity

UK data is limited. Many European studies have found *S. torminalis* to be genetically diverse within and between populations with strong gene flow. Levels of between populations show a strong decrease with latitude, diversity between Danish populations was higher than found in French populations due to larger populations and increased gene flow. In contrast, genetic diversity within populations shows a reverse pattern with allelic diversity being lower in the north compared to France. In part due to greater clonal reproduction in the north but also because the central populations are larger and hold higher genetic variation [7-10]. In Britain, it has lower genetic diversity than in mainland Europe: Seven different plastid DNA types in Britain (shared with French and Spanish populations) were identified compared to the 25 haplotypes identified through Europe [7,11].

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## Small leaved lime (*Tilia cordata* Mill.)

### 2021 Status

Three registered stands. May be concerns with seed viability and trueness to type.

### Recommended seed production approach(es)

Review existing and new stand data to select, assess, register, and manage up to 10 new *in-situ* Seed Stands. Stands should cover populations from across the range in different environmental conditions and from some smaller woodland. Sites with *Tilia platyphyllos* and hybrids, plus those close to populations of unknown origin should be avoided.

### Deliverables

Network of registered *in-situ* Seed Stands covering the full native range of *Tilia cordata*, ideally managed to improve seed production.

### Species information

#### Description

Native, deciduous, large tree, with a typically a narrow crown and habit. Many highly fragrant flowers are produced in mid-summer. Each flower cluster as a long leafy, subtending bract and 5 to 11 white/pale flowers. The fruit is a small, smooth, nut-like drupe containing one, or sometimes two, brown seeds. It has hairs in the vein axils on the lower surface of the heart shaped leaf and trunk is typically free of suckers and epicormic growth.

#### Distribution

Widespread and often scattered. Regarded as non-native both in Scotland and Ireland; the northern limit of the species is around the Lake District region and North Yorkshire [1]. It has been widely planted within and outside of its natural range, especially as amenity trees and in parks. Generally lowland species but reaching c. 600 m in Cumbria [2].

#### Site characteristics

It can occur on a wide range of soil types from sandy, infertile sites to heavier clays but favours good, loamy sites on relatively neutral to slightly acidic soils. It is quite drought tolerant, has high cold tolerance, very shade tolerant but is not tolerant of exposure. Stands are usually quite small and often occur as coppice or as a component of mixed forest, especially with oak, beech and ash. Frequently on steep slopes and cliffs. Planted in avenues and as street trees. Indicator of ancient woodland.

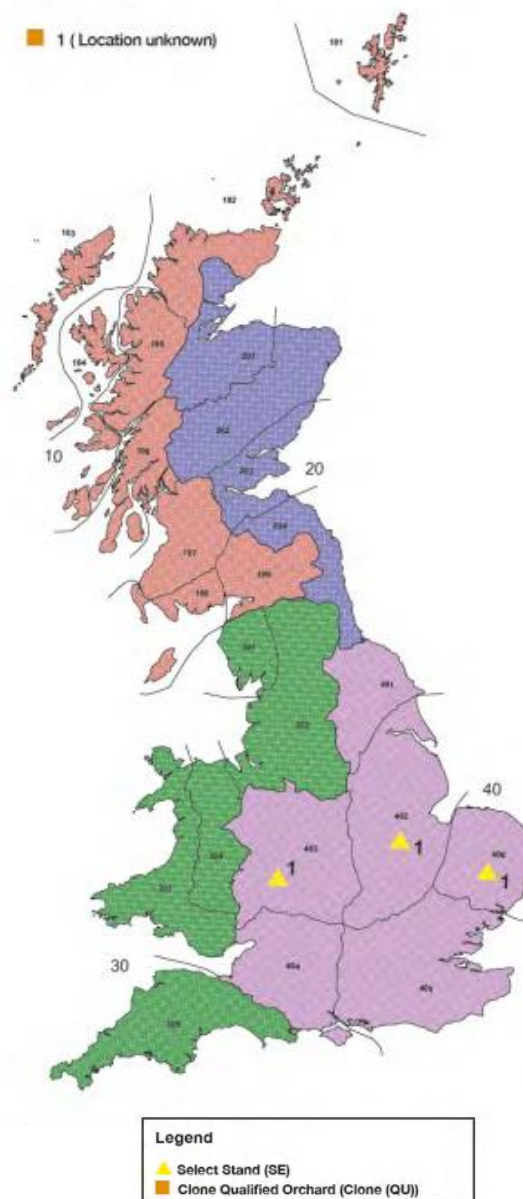
#### Life history

## Small-leaved lime

*Tilia cordata* (tco)

### SUMMARY

3 Seed Stands - 20.50 hectares  
1 Clone Qualified



**Dispersal:** Effective geneflow. Predominately insect pollinated. Seed dispersed by wind [3].

**Reproduction mode (s):** Mixed. Sexual - predominately outcrossing. Monoecious, hermaphrodite flowers. However, rarely set fertile seed except during the warmest summers, due to either a failure of pollination [4] or of fruit development [5]. Most years are infrequent. Asexual - clonal reproduction via layering is frequent.

**Sexual reproductive age:** 12+ years when open grown, 25+ years in woodland.

**Longevity:** Long lived, 500+ years, as coppice for millennia [6].

**Ploidy:** Diploid ( $2n = 82$ ).

### Threats

**Fragmentation:** Moderately fragmented distribution [3]. Plantings likely to obscure native range.

**Alien plantings:** Widely planted in natural, and as an ornamental plant in historic and domestic settings.

**Domestication:** Ornamental forms and varieties developed.

**Hybridisation:** Readily hybridises with *Tilia platyphyllos*;

*Tilia x europaea* (syn. *T. x vulgaris*).

**Clonal reproduction:** Frequent - layering of adventitious shoots or branches. Partially clonal throughout its UK range [7] Key consideration when selecting populations.

**Major pests or diseases:** No although several *Phytophthora* species can cause bleeding cankers.

### Adaptive variation

**Very limited UK data.** Segregation of *T. cordata* and *T. platyphyllos* along environmental gradients is reported [8]. Edge Hill University, Lancashire is examining the links between temperature, phenology, clonality and fertility in *T. cordata* on a local and national scale in order to predict the likely implications of climate change for this species. In a long-term study of populations, all populations including those in the Lake District, show some seed fertility in every year surveyed. The two northern populations typically show lower levels of fertility in any given year, though this is not universal, and variation was found in fertility when comparing the woods in the same area. Fertility figures fluctuates widely between years [9].

There are no provenance trials in Britain nor reports found for continental Europe. Earlier budburst response to warmer springs has been reported for Ireland, Estonia and Lithuania, and later leaf fall in Lithuania. However, phenological sensitivity was reported not to be high as early leafing species. In comparison with the climatic behaviour of most tree species, the high tolerance of *T. cordata* to heat waves or drought events is a significant advantage. Its strong rooting behaviour should also limit the impact of windstorms on mature trees [10].

### Genetic diversity

In studies of native populations in the Limewoods of Lincolnshire, high levels of genetic diversity were reported within populations and low genetic differentiation between populations. Comparison with populations from outside Lincolnshire showed similar genetic diversity with 82% within populations and 4% amongst populations. Weak isolation by distance was identified. Hybrids of Small leaved lime and Large leaved lime (*T. platyphyllos*) hybrids were also reported [11]. In contrast, a wider study of microsatellite study British *T. cordata* and populations and *T. platyphyllos* found a high degree of genetic diversity within and between species. Gene flow among populations appeared limited, with a consequent significant structure [12]. Fine-scale spatial genetic structure has been

assessed in 23 stands across a latitudinal gradient. Genetic diversity is high even in mostly clonal populations and environmental constraints are able to modify, directly or indirectly, the relative importance clonal growth versus recruitment from seed [9]. A recent European study found that clonal reproduction was limited in the populations studied, but leading range-edge populations contained more clones than populations sampled from lower latitudes. Trees further apart than 26m are unlikely to be clones and those further apart than 61m are not likely to be closely related [13]. The distribution and frequency of the chloroplast haplotypes in European studies suggested low genetic differentiation between the populations, although there was some evidence of weak phylogeographic structure [14].

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## Spindle (*Euonymus europaeus* L)

### 2021 Status

No registered stands.

### Recommended seed production approach(es)

Identify autochthonous sites avoiding introduced and clonal populations especially in proximity to habitations and recent woodland/hedge plantings.

Identify, register, and manage 10 *in-situ* Seed Stands.

Create Source-identified Seed Stands. Sampling should include populations from across the range in different environmental conditions.

#### Per Seed Stand:

Number of source populations: 12.

Number of mother plants per population: 20.

Seedlot type: bulked provenance (combined seed from 20 mothers per population).

Target number of seedlings per population: 50.

### Deliverables

Increased range of registered *in-situ* Seed Stands.

New Source-identified Seed Stands established.

## Species information

### Description

Native, much-branched, non-spiny, deciduous shrub or small tree with vivid cerise/red capsules containing fleshy orange seeds. Young shoots and twigs are 4-angled, and leaves turn scarlet in the autumn.

### Distribution

Widespread and continuous in southern Britain becoming fragmented to north and west of range. The extent of its native range is unclear especially in Scotland. Lowland species with upper limit of c.380m [1]. Widely planted and naturalised outside native range.

### Site characteristics

Frequently found in hedges, scrub, open deciduous woodland and woodland edges on fertile soil at higher pH values, especially free-draining base-rich soils, particularly those overlying chalk and limestone. It is winter hardy and shade tolerant. In ancient woodland it occurs as an understorey shrub, often with *Fraxinus excelsior*, *Acer campestre* and *Quercus* species, and in open scrub over limestone with *Cornus sanguinea* [2]. It is also planted in landscape schemes, hedgerows and gardens.

### Life history

**Dispersal:** Effective geneflow [3]. Insect pollinated. Seed dispersed predominately by birds (and mammals).

**Reproduction mode (s):** Sexual - outcrossing. Gynodioecious, having female flowers on some individual plants and hermaphrodite flowers on others [2].

**Sexual reproductive age:** 4-5 years.

**Longevity:** Long lived, 100+ years [4].

**Ploidy:** Tetraploid ( $2n=64$ ) [3].

### Threats

**Fragmentation:** Potentially in parts of range.

**Alien plantings:** Very widely planted in hedges, new woodland and urban settings.

**Domestication:** Several ornamental varieties planted in gardens and parks.

**Hybridisation:** Potentially with alien populations and ornamental varieties.

**Clonal reproduction:** Through layering and root suckers, especially in hedges.

**Major pests or diseases:** No.

### Adaptive variation

No UK data.

### Genetic diversity

No UK data.

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## Wayfaring tree (*Viburnum lantana* L.) (*V. lobatum* Lam.)

### 2021 Status

No registered stands.

### Recommended seed production approach(es)

Identify autochthonous sites to avoid hybrids and introduced populations especially in proximity to habitations. Create a Source-identified Seed Stand. Use resources from the Millennium Seed Bank if possible.

#### Per Seed Stand:

Number of source populations: 12.

Number of mother plants per population: 20.

Seedlot type: bulked provenance (combined seed from 20 mothers per population).

Target number of seedlings per population: 50.

### Deliverables

Seed Stand established.

## Species information

### Description

Native, shrub with dense habit sometimes forming a small, single stemmed tree which is deciduous when mature but tends to be evergreen when juvenile. Cream coloured flowers and red to turning black when ripe, flattened oval drupes. Two varieties occur naturally in Britain: var. *lantana* and var. *glabratum* Chab. (= var. *viride* Kern.) [1].

### Distribution

Widespread in southern England and in southern Wales but fragmented. The extent of its native range is unclear as the northern limits of its range have become blurred due to alien plantings. The status of some populations can be difficult to determine. Lowland species with upper limit of c.285m.

### Site characteristics

Typically found in scrub, woods especially edges and hedges on free-draining, base-rich soils over chalk and limestone. Occasionally on base-rich clays but absent from waterlogged soils. Able to tolerate shade providing moisture is available. It is now frequently planted on roadsides and may also appear when used as a stock for other cultivated species of *Viburnum* [2].

### Life history

**Dispersal:** Effective geneflow [3]. Insect pollinated. Seed dispersed by birds and animals.

**Reproduction mode (s):** Sexual - predominately outcrossing although selfing is possible. monoecious, hermaphrodite flowers. Asexual reproduction via adventitious roots and layering.

**Sexual reproductive age:** 2 to 5 years.

**Longevity:** Long lived, 20+ years as an individual plant. Longer through vegetative means.

**Ploidy:** Diploid ( $2n=18$ ).

### Threats

**Fragmentation:** Likely in parts of range.

**Alien plantings:** Widely planted.

**Domestication:** Widely planted in hedges. Ornamental forms and varieties developed and planted in gardens and parks.

**Hybridisation:** *V. × rhytidophylloides* (*V. lantana* × *V. rhytidophyllum*, which is widely cultivated) has been found at sites in Kent and Surrey. It is suspected as being planted in new woodland sites as *V. lantana* [1]. Potentially with alien and ornamental forms.

**Clonal reproduction:** Yes - frequency not known.

**Major pests or diseases:** No.

### Adaptive variation

**No UK data.** A study comparing drought tolerance and acclimatisation in hydraulics in forest and garden plants of *V. lantana* found that the xylem's vulnerability to drought-induced embolism was found to be highly plastic. Water potential at 50% loss of conductivity ( $\Psi_{50}$ ) significantly decreased after drought treatment demonstrating considerable acclimation potential suggesting that *V. lantana* does not develop a high resistance to drought-induced embolism a priori but are able to acclimate when extended drought periods occur [4].

### Genetic diversity

**No UK data.** A set of microsatellite markers were developed from *V. dilatatum*, *V. farreri*, and *V. rufidulum* have been found to be transferable to other *Viburnum* species including *V. lantana* and were utilized to characterize the relationships between various taxa [5].

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## Whitebeam (*Sorbus aria* L.) Crantz (syn. *Aria nivea*)

### 2021 Status

No registered stands.

### Recommended seed production approach(es)

Identify autochthonous sites, avoiding introduced populations especially in proximity to habitations and recent woodland/hedge plantings and hybrid populations. Identify, register, and manage 10 *in-situ* Seed Stands.

Create new Source-identified Seed Stand(s). Sampling should include populations from across the range in different environmental conditions.

#### Per Seed Stand:

Number of source populations: 12.

Number of mother plants per population: 20.

Seedlot type: bulked provenance (combined seed from 20 mothers per population).

Target number of seedlings raised per population: 50.

### Deliverables

Registered and managed *in-situ* Seed Stands.

New Seed Stand(s) established.

## Species information

### Description

Native, small to medium-sized deciduous tree or shrub which often develops multiple, slender trunks. The leaves are densely hairy underneath giving the appearance of the leaf underside being white. The tree has clusters of five petalled, white flowers and the fruit are to orange to scarlet globose pomes with many lenticels on the skin [1].

### Distribution

*S. aria* is widespread in S. England and variable elsewhere becoming increasingly fragmented and scarce in western Britain. Native of southern England as far west as Dorset. It is widely planted as an ornamental tree, often as one of its cultivars, and widely naturalised. Generally lowland species but reaching 455m [2].

### Site characteristics

Usually prefers moist but well-drained, neutral to basic (alkaline) fertile, lime-rich soils. Its deep root system makes it also resistant to drought. It is a light-demanding tree, which normally occurs in semi-shade habitats, open deciduous woodlands or scrublands, where this species is often recorded on the edges and only rarely occurs in deep shade. It occurs relatively rarely in very acid and very alkaline soils or in habitats with light and sandy soils, as well as in heavy clay soils [1].

## Life history

**Dispersal:** Effective geneflow. Insect pollinated. Seed dispersed predominately by birds (and mammals [3]).

**Reproduction mode (s):** Sexual - predominately outcrossing. monoecious, hermaphrodite flowers. Gametophytic self-incompatibility system [4]. Asexual - via root suckers [5]. Potentially via apomixis (asexual reproduction). A prevalence of apomictic reproduction can result in clonal groups of genetically identical individuals. It establishes freely from seed when browsing is absent.

**Sexual reproductive age:** 10+ years.

**Longevity:** Long lived - 200 years [1].

**Ploidy:** Diploid ( $2n=34$ ) [4].

## Threats

**Fragmentation:** Potentially in parts of range. Plantings likely to obscure native range.

**Alien plantings:** Very widely planted in natural and domestic settings.

**Domestication:** Many wild ornamental forms and varieties developed.

**Hybridisation:** Hybridization with other species of the Sorbus genus occurs predominantly as wild service tree (father) to whitebeam (mother). It is rarely followed by cytoplasmic introgression [5]. However, the Avon Gorge, Bristol, UK, is a world 'hotspot' for Sorbus diversity and home to diploid sexual species including whitebeam, and polyploid apomictic species. Apomictic polyploids can utilize pollen from *S. aria* in pseudogamous seed production [6].

**Clonal reproduction:** Infrequently via root suckers and apomixis.

**Major pests or diseases:** No.

## Adaptive variation

**No UK data.**

## Genetic diversity

A high level of genetic variability was detected in progenies from *S. aria* in the Avon Gorge study [6]. A population study in Poland using 13 nuclear microsatellites, found high genetic variability and high level of differentiation [7]. In contrast, a study of populations in the Canary Islands, found high diversity in the diploid populations but the triploid populations presented lower levels of genetic variability, with a significant degree of fixed heterozygosity, possibly due to asexual reproduction, mainly by apomixis. The reproductive biology and ploidy appear to be responsible for the levels of genetic variability in *S. aria* [8].

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<https://doi.org/10.1007/s11295-014-0713-5>

## Wild apple (*Malus sylvestris* Mill.)

### 2021 Status

No registered stands. Concerns raised about trueness to type.

### Recommended seed production approach(es)

Individuals have been identified from across the range using a combination of morphological characters and genetic markers [4,9], to create a northern Britain Seed Orchard. The same approach should be adopted to create southern Britain Seed Orchard especially as the frequency of hybridisation is likely to be higher.

Identify 80 native sites (avoiding non-native and hybrid populations where possible), select and collect graft wood from up to three trees per site. Sites should be located across Regions 30 and 40. Propagate three replicates of each tree by grafting and grow on as planting material for a clonal Seed Orchard. Genotype all individuals using the previously used set of markers [9] to identify pure *M. sylvestris* individuals prior to selection for use in Seed Orchard(s).

Populations are very small and fragmented but if large enough populations can be found these should be registered as Seed Stands.

### Deliverables

True-to-type wild apples identified and propagated to create Southern Britain Seed Orchard(s) and potentially for direct use in conservation programmes.

Wild apple database for southern Britain established.

Register *in-situ* Seed Stands.

## Species information

### Description

Native, small to medium sized, thorny stemmed, deciduous tree with often a large, very dense, complex crown. White to blush pink flowers and small apples (<30mm).

### Distribution

Widespread and predominantly continuous distribution [1]. Rare and more fragmented in northern Britain. Widely planted but difficult to identify trees of alien and hybrid origin. Found up to 380m [2].

### Site characteristics

Able to tolerate a range of soil conditions and pH, but prefers moderately fertility, fresh, calcareous soils. Cannot grow in very dry, sandy soils or waterlogged soils [3]. As a light demanding species with a very weak competitive ability, wild apple exist mostly at the



edge of woodland, open spaces within woodland, in wood pasture, in farmland hedges or on very extreme, marginal sites including flood plains.

### Life history

**Dispersal:** Effective geneflow. Insect pollinated. Seed dispersed by animals and birds.

**Reproduction mode (s):** Sexual - outcrossing. monoecious, hermaphrodite flowers. Gametophytic self-incompatibility system to prevent selfing. Asexual - able to propagate clonally from layering.

**Sexual reproductive age:** 5 years onwards.

**Longevity:** Quite long lived, up to 150 years as an individual tree. Longer through clonal means.

**Ploidy:** Diploid ( $2n=34$ ).

### Threats

**Fragmentation:** Likely in parts of range.

**Alien plantings:** Very widely planted.

**Domestication:** Wild apple is a progenitor of the domestic (eating) apple – this being a hybrid between a sweet apple from eastern Asia and both European and Asian wild (crab) apples [4].

**Hybridisation:** Potentially with alien populations, other apple species, hybrids and ornamental forms.

**Clonal reproduction:** Yes, via layering (resprouting) - reported in 20% of mature trees following collapse of main limbs or stem providing contact is made with the ground [4].

**Major pests or diseases:** No.

### Adaptive variation

Very wide climatic tolerances reported for northern Britain but UK adaptive variation data lacking [4]. A study in Denmark found significant genetic variation in spring flushing within and among populations. However, level of genetic differentiation located among populations was low [5]. The authors proposed that the variation among populations is likely the result of natural selection and neutral selection and neutral processes simultaneously. In Belgium, whilst some geographical pattern of genetic differentiation among wild apple populations exists, most variation is concentrated within samples [6].

### Genetic diversity

Wild apple study of northern Britain populations using 14 SSRs, found quite high levels of genetic variation in all populations, with no genetic structure to individual populations and low genetic differentiation between populations [4]. This finding is in agreement with nuclear DNA studies of populations in Belgium [6] and France [7], and cpDNA study of European populations [8]. Hybridisation was reported as an important factor in the Northern Britain populations: 70% of samples could be considered pure *M. sylvestris*, 27% showed varying degrees of introgression from *M. domestica* and 3% were pure *M. domestica*. However, the gene pools were distinctive [9]. Hybrid apples (*M. domestica* ×

sylvestris) are reported to make up a significant proportion (7–36%) of populations of wild crab apples across a range of European countries [10].

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## Wild privet (*Ligustrum vulgare* L.)

### 2021 Status

No registered stands.

### Recommended seed production approach(es)

Identify autochthonous sites to avoid hybrids and introduced populations especially in proximity to habitations. Consider using collections from the Millennium Seed Bank if possible.

Create regional Source-identified Seed Stands. Sampling should include populations from across the range in different environmental conditions.

#### Per regional Seed Stand:

Number of source populations: 12.

Number of mother plants per population: 20-30.

Seedlot type: bulked provenance (combined seed from 20-30 mothers per population).

Target number of seedlings per population: 50.

Register and manage Seed Stands if they are wild-type and diverse.

### Deliverables

Regional seedling Source-identified Seed Stand(s) established.

*In-situ* Seed Stand(s) registered.

## Species information

### Description

Native, small semi-evergreen or deciduous shrub with typically dense arching habit. Produces strongly smelling panicles of white flowers and very small black berries.

### Distribution

Widespread and continuous in England and Wales, native populations may occur elsewhere. Naturalised outside of its native range. It can be difficult to decide if some populations are alien or native.

### Site characteristics

It prefers direct sunlight but is shade tolerant and will invade forest edges and other shady areas, as well as degraded areas [1]. It is tolerant of most soil types, however it does particularly well of well-drained calcareous and base-rich soils. Native in hedgerows, woodland and scrub. It is also often planted, particularly in hedges and woodland, and occurs as a garden escape and a relic of cultivation. Found up to 0-490m [2].

## Life history

**Dispersal:** Effective geneflow [3]. Insect pollinated. Seed dispersed by animals and birds.

**Reproduction mode (s):** Sexual - outcrossing. monoecious, hermaphrodite flowers.

Asexual reproduction via root suckers and layering.

**Sexual reproductive age:** 5+ years.

**Longevity:** Long lived.

**Ploidy:** Diploid (2n=46).

## Threats

**Fragmentation:** Likely in parts of range.

**Alien plantings:** Widely planted.

**Domestication:** Widely planted in hedges and used for game cover in woodland.

Ornamental forms and varieties developed and planted in gardens and parks.

**Hybridisation:** Potentially with other species, alien and ornamental forms [4].

**Clonal reproduction:** Yes - frequency not known.

**Major pests or diseases:** No.

## Adaptive variation

**No UK data.** A study comparing drought tolerance and acclimatisation in hydraulics in forest and garden plants of *L. vulgare* found that the xylem's vulnerability to drought-induced embolism was found to be highly plastic. Water potential at 50% loss of conductivity ( $\Psi_{50}$ ) significantly decreased after drought treatment demonstrating considerable acclimation potential suggesting that *L. vulgare* does not develop a high resistance to drought-induced embolism a priori but are able to acclimate when extended drought periods occur [5].

## Genetic diversity

**No UK data.** A study in Ohio, USA has examined genetic, age and spatial structure to improve management of *L. vulgare*. Using three cpDNA markers, it was found that most of the species and cultivars in nurseries were highly genetically different from the individual *L. vulgare* plants sampled in natural areas. There were also high levels of genetic variation between different *Ligustrum* species and cultivars. The most polymorphic marker identified 16 haplotypes. Five haplotype per marker were only found within cultivated nursery stock. The high levels of genetic diversity were recorded between invasive plants in natural areas and cultivars in nurseries, so interspecific hybridisation was considered as a possible explanation [4].

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## Yew (*Taxus baccata* L.)

### 2021 Status

One registered stand.

### Recommended seed production approach(es)

Identify 10 diverse, native populations including isolated and edge populations with at least 20 seed producing individuals at each site. Use Millennium Seed Bank resources, if possible, to locate some sites. At larger sites, ensure mother trees are at least 50m apart. Discuss management with owners. Register stands and encourage seed collection.

### Deliverables

10 *in-situ* Seed Stands identified and registered.

### Species information

#### Description

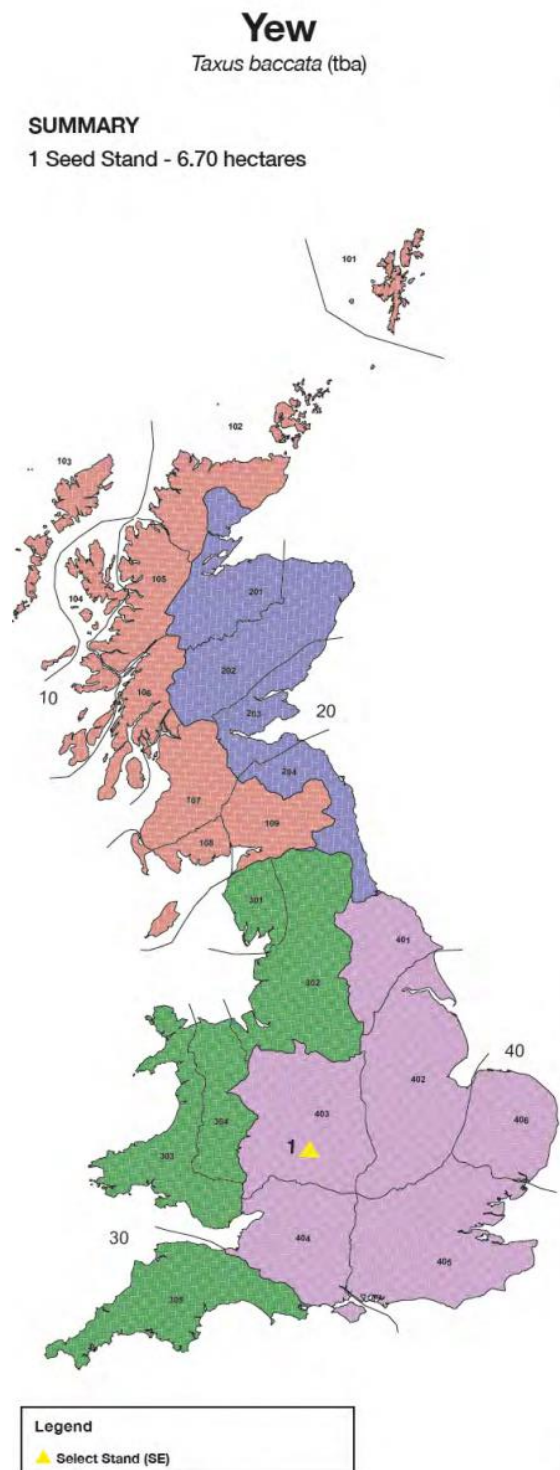
Native, medium size in height, often large in girth, evergreen conifer tree typically with multiple trunks and spreading, rounded or pyramidal canopy. Short needles, thickly set in two ranks on opposing sides of the shoots. Each seed contained within a fleshy red aril.

#### Distribution

Widespread in lowland Britain but with fragmentation. Absent/scarce in parts of northern England and Scotland. Grows up to 425m above level in England and Wales.

#### Site characteristics

Prefers clayey, loamy or calcareous soils which are naturally moist but free draining but occurs locally over acidic rocks. Grows well in full sunlight. Extremely shade and drought tolerant. Intolerant of severe frost. It can form pure stands; ancient woods of *T. baccata* occur on the chalk in S. England, especially along the sides and bottom of dry valleys and on scarp slopes [1]. In mixed deciduous woods on limestone and chalk, usually as individual trees or small groups. Very frequently found in churchyards, sometimes in parks, large gardens and hedges (typically absent from agricultural livestock hedges as plant is poisonous to livestock).



## Life history

**Dispersal:** Effective geneflow [2]. Wind pollinated. Seed dispersed by predominantly birds (and animals).

**Reproduction mode (s):** Outcrossing. Normally dioecious, rarely monoecious [1].

**Sexual reproductive age:** 20+ years.

**Longevity:** Long lived. 500+ years.

**Ploidy:** Diploid ( $2n = 24$ ).

## Threats

**Fragmentation:** Likely in parts of range.

**Alien plantings:** Widely planted for amenity and conservation.

**Domestication:** Many ornamental varieties planted in gardens and parks.

**Hybridisation:** Potentially with alien populations and domesticated forms.

**Clonal reproduction:** Very infrequent. Advantageous roots may form when branches touch ground.

**Major pests or diseases:** No.

## Adaptive variation

UK data is lacking. A recent study combined information from two independent sources; phenotypes from 26 Spanish natural populations in a common environment and genomic data from 12 natural populations selected across the species European distribution range, include three British populations. Growth differences among populations in a common environment, and phenological patterns of both shoot elongation and male strobili maturation, were associated with climate clines, providing evidence for local adaptation from cold, inland, continental climates to milder, temperate, and coastal ones. Information on over 25,000 SNPs from c. 1,200 genes to infer the demographic history and to test for molecular signatures of selection at different levels: SNP, gene, and biological pathway, confirmed an overall demographic history of population decline, but also found evidence for putative local adaptation at the molecular level [3]. A European wide study of 238 populations including 8 from Britain, found that geography and climate have played a significant role in shaping genetic structure of yew. European samples diverged into two groups (Western, Eastern) with geographic isolation during glacial periods and environmental adaptation during interglacial periods at the origin of genetic divergence between both groups. Contrary to other studies, results did not reveal a direct effect of rainfall variables on genetic divergence, but rather pointed to a major effect of the temperature [4].

## Genetic diversity

UK populations have been studied using nuclear microsatellite markers and seed collections made by the UK National Tree Seed Project. The analysis of genetic structure revealed little differentiation among populations, with high admixture between the two detected genetic clusters, low-moderate  $F_{ST}$  values among populations and genetic variation mostly partitioned at the individual level. There were no geography patterns. This suggests that high gene flow is effective in homogenising populations. Heterozygosity was

lower than expected for a dioecious obligate outbreeder. The seed collections were representative of wild populations in terms of allelic capture, including rare and locally common variants [5].

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