Eucalyptus - Part 1

Species with forestry potential in the British Isles

John Purse and **Andrew Leslie** continue our species profile series with a two-part in-depth consideration of *Eucalyptus*, starting by looking at which species are best suited to UK forestry.

The genus *Eucalyptus* is part of the Myrtaceae family and contains over 700 species with all but two tropical species being endemic to Australia (Brooker, 2000). The wide range of habitats present in Australia has fostered a high degree of genetic variation both between and within species (Florence, 2004). Starting in the mid-19th century, a wide range of *Eucalyptus* species have been planted in many countries, including Britain, facilitated by improved understanding of the taxonomy of the genus and increasing availability of seed of well-defined origins (Zacharin, 1978).

Until the 1950s interest in *Eucalyptus* in the UK was focussed on their arboricultural potential on estates and in gardens. The performance of 19th century plantings were comprehensively reviewed by Elwes and Henry (1906-13), and again by Martin (1948) and MacDonald et. al. (1957). Trial forestry plots were first established in Ireland in 1909 (Mooney, 1960), although not until the 1950s in the UK (MacDonald et. al., 1957). Plantings made after 1950 were reviewed by Evans (1980). All these plantings generated interest because of the fast growth of many species. They also highlighted that most species are insufficiently hardy to survive for long in Britain, especially in colder inland areas. Nevertheless, a few species have proved to be sufficiently hardy to survive extremely cold winters. Some individuals of a small number of species have proved to be long-lived, and have grown to large dimensions. The oldest specimen still living is probably an *Eucalyptus urnigera*, recorded as having been planted in 1881 in the grounds of Stonefield Castle, Argyll (TROBI, 2015). The Tree Register of the British Isles (TROBI) database provides a host of other examples, some of which have outstanding form as well as impressive dimensions.

In recent years there has been increased interest in using woody biomass for energy, and in alternative species for UK forestry due to the concerns about the impact of climate change (Read et. al., 2009), and due to the risk of growing traditional forestry species because of new pests (Logan et. al., 2003) and diseases (Sturrock et. al., 2011). This has led to renewed interest in the use of certain *Eucalyptus* species in forestry in Britain. Some very interesting and impressive trial stands have resulted, as well as poorly-established and failed plantings. In this article we review the *Eucalyptus* species that appear to have potential for forestry in Britain. In the next issue we will evaluate forestry trials and recent plantings in Britain, and prospects for more widespread use of *Eucalyptus* species (Purse and Leslie, 2016).

Cold damage

All the earlier reviews (cited above) on growing eucalypts in the British Isles have recognised that the greatest threat is cold damage. Therefore, matching species to site on the basis of experience is crucial to minimise this risk. This requires a good appreciation of the extreme climatic conditions experienced at any site over an extended period. The mechanisms of cold adaption in eucalypts are complex, and damage can be caused by a number of factors (Purse, 2013). However, the key factors are (a) air temperatures, which vary greatly with height above ground in still conditions; (b) the degree of hardening that has occurred (hardening appears to be promoted by cool nights); and (c) cool (but not freezing) soil temperatures, especially when accompanied by wind, as this can lead to desiccation of young trees due to poor uptake of water by cool surface roots (Almeida et. al., 1994). *Eucalyptus* species and provenances vary considerably in the rate and extent to which they harden and respond to cold damage; some

species, notably *E. gunnii*, may simply drop their leaves in response to severe cold, but recover more or less completely within 12 months (e.g. Bateman, 1899; Venison, 1963). Most *Eucalyptus* species will coppice, or sprout from epicormic buds on the stems, if cold damage does not affect viability of the root system and/or cambium (Evans, 1980). The historic occurrence and frequency of absolute minimum temperatures in any location appears to be a reasonable guide to the *Eucalyptus* species that may be grown at that location.

Discussion on individual species

The species described in this section follow current taxonomic descriptions. These frequently differ considerably from those used in older literature.

Cider gum (*Eucalyptus gunnii* Hook. f.)

Cider gum, endemic to the mountains of Tasmania (Figure 1a) has been widely planted in Britain for over 150 years (Purse, 2010a). It is recognised as a particularly cold-tolerant species that can grow to considerable dimensions. It was the first species to become popular for the production of cut foliage in Britain and Ireland, and in the past 40 years has become the most recognised *Eucalyptus* species, thanks to its widespread planting in gardens throughout the country. Such plantings, particularly in colder parts of Britain, are a testament to its hardiness.

Two subspecies (ssp *gunnii* and ssp *divaricata*) have been recognised (Potts et. al., 2001). Alpine cider gum (*Eucalyptus archeri* Maiden & Blakely) is very similar and closely related, and has usually been included in species trials. *E. gunnii* is quite variable in hardiness, vigour and form; screening in both France and Britain has generally led to provenances from within ssp *divaricata* being identified as the most hardy (Evans, 1986; Cauvin and Potts, 1991). These provenances as well as others were tested extensively by Forest Research in the 1980s (Evans, 1986) and surviving trees generally have poor form in trials. Clonal selections combining good form with high cold tolerance were made in France in the 1980s (ADEME, 1998), but these selections are no longer deployed operationally.

E. gunnii ssp. *divaricata* is classified as endangered in Tasmania (Potts et. al., 2001), and the natural stands there have been closed to seed collection since the late 1990s. The main sources of *E. gunnii* seed of both subspecies for the past 20 years have been managed stands in Southland, New Zealand, though small quantities of ssp. *divaricata* are also available from a managed stand in Tasmania. Subspecies *gunnii* has been most commonly planted in Britain in recent years, and the New Zealand source is notable for its poor form. Use of this source may also be the reason why more recent plantings of the species appear to be less cold-tolerant than earlier introductions.

The principal limitation on use of *E. gunnii* in forestry is its exceptional palatability to browsing mammals, which has also been recognised in Australia (McGlone, undated) and Ireland (Neilan and Thompson, 2008). Given the availability of other species with similar or better characteristics (notably *E. glaucescens*, and also *E. urnigera*), it is unsurprising that interest in the species for production forestry is rather limited today.

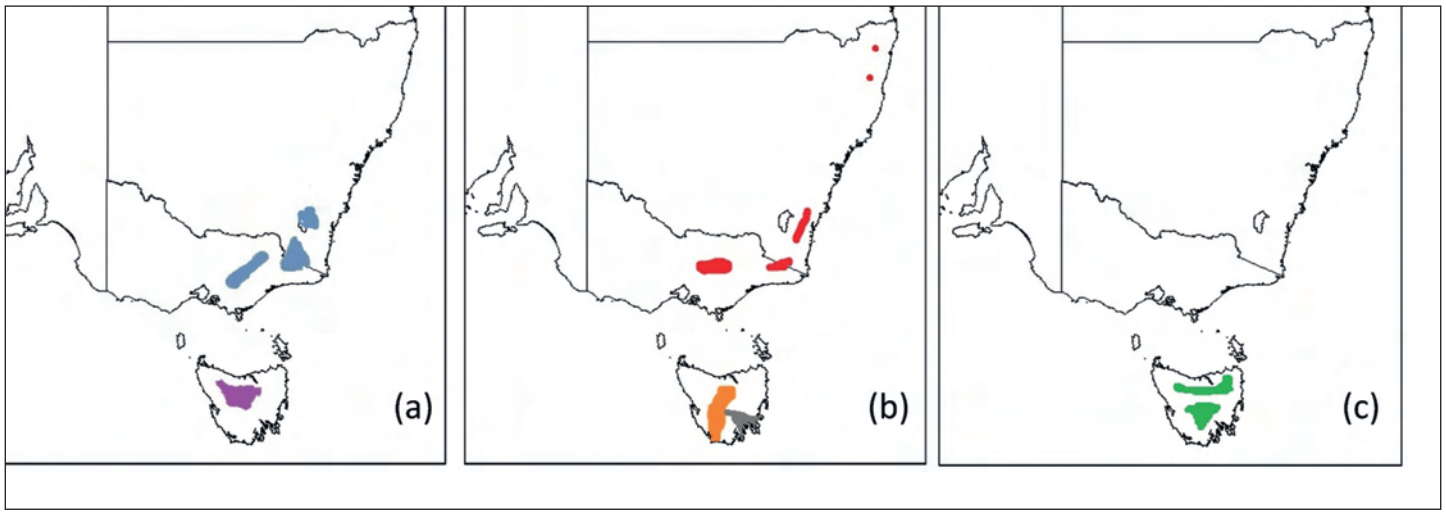

Figure 1. Distributions of selected cold-tolerant eucalypts: (a) E. glaucescens (blue) and E. gunnii (purple), (b) E. johnstonii (grey), E. nitens and E. denticulata (red) and E. subcrenulata (orange), (c) E. rodwayi (green) (Brooker and Kleinig 1990).

Figure 2. Eucalyptus gunnii ssp. divaricata age 8 years in a demonstration planting in north Kent. The poor form is typical of this subspecies when grown from seed.

Tingiringi gum (*Eucalyptus glaucescens* Maiden & Blakely)

Tingiringi gum has proved to be the most popular eucalypt species for forestry planting in Britain in terms of sales of plugs in the past five years (Purse and Leslie, 2016). This is due to its exceptional cold tolerance, its unpalatability to deer on some sites, and its adaptability to diverse site types. Most of the few trees that exist in older trials and specimen plantings in Britain have very impressive form and dimensions.

The species occurs naturally in a number of small and widely-scattered scattered populations in alpine areas of Victoria and New South Wales, extending as far north as the Australian Capital Territory (ACT) (Kirkpatrick, 1976) (Figure 1a). The populations are distinctive, ranging from tall trees in the southernmost provenances in central Victoria, to shrubs in the northernmost populations. Many of the populations have been badly affected by bushfires in recent years, and all are now protected. The species is not widely cultivated worldwide, and until 2010 the main commercial interest in the species has been for production of cut foliage in Britain and Ireland. The species has been very successfully grown in small plots and shelterbelts in cold parts of southern New Zealand, and these provide the only commercial supplies of seed today.

E. glaucescens was first introduced to Britain in 1959, at Bovey Tracey, Devon (Barnard, 1966). Two trees from the early (pre-1963) plantings there still exist, and are the country champions for height and girth (TROBI, 2015). Seed from these trees was collected during the 1970s, and led to some amenity plantings and small forestry trials. The surviving trees from this source in trial NF38 (p1980) conducted by Forest Research in the New Forest are particularly impressive.

Six provenances of *E. glaucescens* were tested by Forest Research in 1981 together with seed sources of *E. gunnii* (Evans, 1986). Poor survival was likely to have been due to poor establishment conditions coupled with very severe winters in 1981-2 and 1984-5, which limits the usefulness of the data generated. However, data from the trials do suggest that the northern provenances (Tinderry, Mt Tingiringi) are less cold tolerant than those from further south, with the

Table 1. County Champion *Eucalyptus glaucescens* of known age in the UK (TROBI 2015) ©TROBI

Location	County	Planting year	Height (m)	Dbh (cm)	Age when measured (years)
Parkside, Prestwich	Greater Manchester	1991	19.00	58	19
Sir Harold Hillier Gardens, Romsey	Hampshire	1987	17.50	42	21
Plas Newydd, Anglesey	Gwynedd	1981	24.00	49	25
Westonbirt Arboretum	Gloucestershire	1982	28.00	76	33
Linn Botanic Gardens, Cove	Argyll & Bute	1971	22.00	80	41
Blue Gums, Lamberhurst	Kent	1971	30.20	63	43
Blue Gums, Lamberhurst	Kent	1971	24.00	70	43
Grey gums, Bovey Tracey	Devon	1959	23.00	150	53
Grey gums, Bovey Tracey	Devon	1959	26.00	124	53

Figure 3. Eucalyptus glaucescens age 32 years in Forestry Commission trial NF38 in the New Forest, Hampshire.

Guthega, NSW origin exhibiting best survival across trials (Evans, 1986). This is consistent with informal observations elsewhere.

Plantings in New Zealand indicate that only the Victorian provenances, and those from Guthega in NSW, grow into large trees. Origins from further north in Australia are less vigorous. Unusually for eucalyptus, the vigorous provenances are very shy to flower and set seed when young (<15 years). This restricts the amounts of seed that can be collected commercially in New Zealand. The older trees at Bovey Tracey flower freely and have capsules that are characteristic of the Victorian provenances, but set very little seed. This suggests that the remaining trees there may be closely related and so fail to cross-pollinate. The little seed that they do produce appears to yield plants that are *E. glaucescens* x *gunnii* ssp *divaricata* hybrids (Purse, 2015a); this is plausible as the parental species flower at a similar time of year (September), and are present in proximity.

Almost all plantings of *E. glaucescens* made in Britain since 2007 have used seed sourced from New Zealand, collected from populations derived either from Guthega or an unknown Victorian location. Both seed sources have given trees of very similar vigour and good form when grown with good establishment conditions on uniform sites. The genetic base of the seed sourced from New Zealand is likely to be limited.

The recent plantings have been on a modest scale in a very wide range of locations, ranging from the thin light soils of Thetford Forest, a very fertile alluvial site in the Severn valley near Upton, the Leighton Estate near Welshpool, and a classic Sitka spruce site in Argyll. In all cases where good establishment conditions have been provided (this includes all the above examples), early growth of the crops has been remarkable and has generated considerable interest. The species has proved to be amongst the hardiest of the eucalypts. The resistance of the species to deer browsing was first noted in Oregon, USA (Hunt, 1983), and has been apparent in Britain too, notably at Rogate Common, West

Sussex, and in Thetford Forest. However, there have also been many examples of it being consumed by deer, and the overall impression is that if deer are sufficiently hungry they will eat it.

Shining gum (*E. nitens* (H. Deane & Maiden) Maiden and Errinundra shining gum (*E. denticulata* I. O. Cook & Ladiges)

These two species are closely related; *E.denticulata* was formerly known as the Errinundra provenance of *E. nitens*. The species can be treated together for most purposes, though there are some significant differences, discussed below. *E. nitens* is a commercially important species, notably in Chile, but also in Spain, Portugal, South Africa, Australia (Tasmania) and New Zealand (Tibbets et. al., 1997). The main use of the species is for production of high quality Kraft pulp, although its basic density is lower than desired, resulting in sub-optimal mill throughput and output when this species is the main feedstock.

E. nitens occurs naturally at intermediate elevations at various locations on the Great Dividing Range between central Victoria and northern NSW (Figure 1b). *E. denticulata* occurs mainly on the Errinundra Plateau in eastern Victoria. The species are shy and erratic seeders in the wild, and essentially all the seed used commercially today comes from managed stands and seed orchards. The sources of *E. nitens* originating from central Victoria and southern NSW are morphologically quite distinct in the juvenile phase, but both sources are well-suited to temperate climates with cool wet winters, including Britain. Seed of these sources is available from Tasmania, New Zealand and Chile. *E. denticulata* has smaller juvenile leaves than *E. nitens*, and starts producing adult foliage at a much earlier age. The only significant source of seed is a former progeny trial that has been converted into a seed production stand in Chile.

In Britain thriving *E. nitens* generally command attention because of their impressive growth rates (Figure 4). A demonstration stand in north Kent gave an MAI of $40 m^3 ha^{-1} y^{-1}$ at 8.3 years (Purse, 2010b). This is probably a record for a tree species in the UK, though typical of a well-grown commercial stand of the species in Chile. The first commercial planting in Britain in 2005 at Rogate Common, West Sussex, is now ready for harvesting. Many of the stems in the planting are of timber dimensions, and some will be used in a sawing trial.

The canopy formed by the juvenile crown of *E. nitens* is impressively large and dense under good establishment conditions, and will readily shade out competing vegetation in the second year following planting. Such large canopies put the young trees at risk of windthrow, but *E. denticulata* with smaller juvenile leaves and much earlier transition to adult foliage is less prone to windthrow on exposed sites.

Figure 4. Coppice with standards? Eucalyptus nitens and mixed hardwood coppice both age 23 years in Cromers Wood, north Kent in 2012.

The unusually large juvenile leaves of *E. nitens* create problems when the trees are planted in tree guards (both spiral and solid). The shoots often fail to emerge from the guards because folded leaves block the exit. An additional problem is that if shoots emerge, the dense crown develops on top of a short unthickened and unbranched stem, leaving the trees very prone to windthrow when young.

It should also be noted that many of the recent failures of *Eucalyptus* in Britain concern plantings of *E. nitens* that have been damaged or killed by cold. Hardened young trees are generally killed by air temperatures below -12°C, although

established trees are rarely damaged by such temperatures. This obviously limits the areas in Britain that are suitable for the species to relatively mild areas – generally within 20km of the coast in southern Britain, and closer to the coast further north. The species requires well-drained sites.

Alpine yellow gum (*Eucalyptus subcrenulata* Maiden & Blakely) and Tasmanian yellow gum (*Eucalyptus johnstonii* Maiden)

Both the yellow gums together with varnished gum (*Eucalyptus vernicosa* Hook.) are endemic to Tasmania (Figure 1b) and form an altitudinal cline, with *E. johnstonii* found at lowest altitudes and *E. vernicosa* at highest. The literature, and records of plantings in Britain, confuse the identity of trees of this group, though the modern taxonomic distinctions between them are clear (Nicolle, 2006). *E. johnstonii* is a large forest tree of good form having very attractive smooth bark (Figure 5). It was formerly of minor importance in Tasmania for timber of good quality (Boland et. al., 1984). It was introduced to Ireland in 1911, and extremely large and handsome trees in stands of unknown age still exist there, notably at Avondale, Co. Wicklow. Mooney (1960) and Neilan and Thompson (2008) recognised *E. johnstonii* as a species with potential for production forestry in Ireland. The species is rare in Britain, but some young trees have performed well on a former Sitka spruce site at Cowal, Argyll, and on a former arable site near Wadebridge, Cornwall. There is a suggestion that the species may not coppice well (Nicolle, 2006). Its hardiness appears similar to that of *E. nitens*.

Figure 5. Eucalyptus johnstonii of unknown age at Avondale, Co. Wicklow, Ireland.

E. subcrenulata, a much more variable species in the wild, is easily distinguished from *E. johnstonii* by its smaller flowers and seed capsules. It is recognised as being very cold-tolerant in both New Zealand and Britain. From early results, Evans (1986) identified *E. subcrenulata* as being a promising species for planting in milder areas of the UK. For production forestry, the interest is in populations that form large trees in the wild (Nicolle, 2006), and which are vigorous in trials. Limited amounts of such seed, originating from Mt Field provenance, are available from New Zealand; this source shows good early growth in trial plantings in UK and Ireland. A number of good trees of unknown provenance exist in the arboretum at Crarae, Argyll. A progeny trial of this species was planted by Forest Research in Haldon Forest, Devon in 1981, and measured in 2010 (Leslie et. al., 2014). Certain families originating from Mt Cattley and Mt Hartz (the latter supplied as *E. johnstonii* but actually *E. subcrenulata* based on the surviving trees) performed exceptionally well. This stand would be an excellent candidate for selective thinning and conversion to a seed production stand.

The potential for both species for forestry in Britain cannot be properly assessed without further trial plantings alongside species such as *E. glaucescens* and *E. urnigera*. Their greatest potential is probably on reasonably well-drained soils in high rainfall areas in the west of Britain.

Swamp peppermint (*Eucalyptus rodwayi* R.T. Baker & H.G. Smith)

Swamp peppermint is endemic to Tasmania, where it occurs in upland areas of impeded drainage, including frost hollows (Nicolle, 2006) (Figure 1c). The sites are similar in character to those occupied by *E. gunnii* ssp. *divaricata*, but it occurs at slightly lower elevations (Potts et. al., 2001). It has been quite widely planted in colder parts of southern South Island, New Zealand, mainly as a shelterbelt on relatively dry, windy sites, but also on ground near watercourses that flood

seasonally. It is notable for its extraordinarily extensive horizontal root system, very apparent when fields adjacent to shelterbelts are cultivated.

The species has attracted attention in Britain for two reasons. First, it is not glaucous at any stage of growth, and has fine, narrow-leaved foliage (Figures 6 & 7). Thus it does not look like a typical eucalypt, and is more like an evergreen willow. This appeals to some landowners looking for fast-growing trees that fit better into the British landscape than those eucalypts with glaucous or grey foliage. The second reason is that it will happily grow on sites that have poor, thin soils and are regularly flooded. The species even seems suited to sites that are inundated with stagnant water for several weeks at a time, even if that water freezes. However, the species has poor vigour when planted on mounds on wet sites. The reason for this is unclear, but may be a consequence of the mounds inhibiting the natural development of lateral roots.

Figure 6. Eucalyptus rodwayi age 7 years growing on river gravel in the Darent Valley, Lullingstone Castle arboretum, Kent.

The species is less cold tolerant than the hardiest eucalypts. Young trees are usually killed to the ground by temperatures of -15°C, though they have subsequently coppiced vigorously. As with other species, older trees are more cold-tolerant. The trees tend to be single-stemmed, but with poor stem form when young. Seed is available in commercial quantities from New Zealand, although the origin is not known, and its genetic base may well be limited. There may be value in comparing a range of provenances in Britain, to see if sources having better form, vigour and cold-tolerance can be identified. The closely-related mainland species, black gum (*Eucalyptus aggregata* H. Deane & Maiden) is reputedly more cold-tolerant and deserves

Figure 7. Eucalyptus rodwayi age 4 years, on a landfill site in north Kent. The soil is a thin clay cap, and the site is waterlogged every winter. Weed control has involved both spraying and mowing.

testing.

Other species

Several other *Eucalyptus* species appear to be as or nearly as hardy as *E. gunnii* and *E. glaucescens*, and have potential as forestry species in Britain. However, older trees are only known in arboreta. The very hardy candidates include *Eucalyptus parvula* L.A.S. Johnson & K.D. Hill, *Eucalyptus urnigera* Hook.f., and possibly *Eucalyptus lactea* R.T. Baker. One further species deserving wider investigation is *Eucalyptus dalrympleana* Maiden. This has been used for forestry in Catalonia in the past, where hardy selections were identified (Ruiz, 1992). Large handsome specimens occur in gardens and arboreta throughout Britain, including some in locations in central England that are potentially cold (TROBI, 2015). Hybrid selections of *E. gunnii* x *dalrympleana* are used commercially in south-west France, and are substantially more productive than *E. gunnii* (ADEME, 1998). A further species that may have potential on milder sites is *E. delegatensis* R.T. Baker (Leslie et. al., 2014). This is a vigorous species and young trees have been successfully milled in New Zealand (Barr, 1996).

Three of the sub-species of snow gum (*Eucalyptus pauciflora* Sieber ex Speng.) have been identified as having greater hardiness than *E. gunnii* in Britain (Evans, 1986). However, they grow more slowly than *E. gunnii* in trials; the best origins in three trials in southern England grew at 7-10m^3 $ha^{-1}y^{-1}$ at an age of between 24 and 26 years (Leslie et. al., 2013) and generally have poor form. It seems unlikely that they will have a role in forestry but their attractive foliage and bark make them suited to horticultural uses (Evans, 1986).

Pests and diseases

Eucalypts in Britain and Ireland have been relatively free of pests and diseases. A eucalyptus psyllid (*Ctenarytaina eucalypti*) has been present in Britain since the 1920s, and caused damage to foliage plantations in the 1980s. It is now largely controlled biologically by a released parasitic wasp (*Psyllaephagus pilosus*) (Hodkinson, 1999), and is of little consequence in forestry. A eucalyptus gall wasp (*Ophelimus maskelli*) was found in London in 2005 (Tilbury and Jukes, 2006) and has since spread (Badmin, 2009). This wasp has been a serious defoliator of eucalypts around the Mediterranean, but is now controlled using a parasitic wasp (*Closterocerus chamaeleon*) originally released in Israel and already present in Portugal (Branco et. al., 2009). The gall wasp has not become a cause for concern in Britain.

A previously undescribed species of Chrysomeline leaf beetle (*Paropsisterna selmani*) became established in south-west Ireland around 2007, and as was predicted it spread rapidly. It has caused quite severe damage to specimen eucalypts and the eucalyptus foliage plantations in Kerry and West Cork, but damage to trees in south-east Ireland has so far been less severe. The beetle was first reported in UK in London in 2012 (Reid and de Little, 2013). The beetle and its characteristic damage were observed in the eucalyptus plantings at Rogate Common, West Sussex in autumn 2015 (Purse, 2015b), but the damage there is minor although widespread. The pattern of damage suggests that a predator may be already controlling the beetle; a plausible candidate predator would be the harlequin ladybird (*Harmonia axyridis*), which has not yet reached south-west Ireland.

Eucalypts in Britain are generally free from fungal pathogens, except in nurseries where dank winter conditions under cover easily lead to proliferation of *Botrytis* and powdery mildew. *E. archeri* managed in a manner akin to short rotation coppice (SRC) willow was killed by silverleaf disease (*Chondrostereum purpureum*) following infection after coppicing of one-year old plants (Mitchell et. al., 1993), but such damage is uncommon on larger coppice stumps; the eucalyptus cut foliage industry would not exist if silverleaf disease was a significant problem.

It is likely that further pests and diseases will arrive in future, and more extensive planting of eucalypts would facilitate their spread. Other serious insect pests of eucalypts are present in southern Europe, and have spread rapidly in recent years, although biocontrol measures are proving effective. Britain's cooler climate may mitigate their impact if they do reach our shores. *Mycosphaerella cryptica* and *M. nubilosa*, which are relatives of *Dothistroma septosporum* (red-band needle blight), have become serious fungal diseases on *E. globulus* in northern Spain, and are occasionally seen on foliage crops of certain species of *Eucalyptus* in Cornwall, but Britain's cooler summer climate is likely to restrict their impact.

The main pest problem encountered with eucalypts in Britain is damage by browsing mammals: rabbits (*Oryctolagus cuniculus*), hares (*Lepus europaeus*) and deer (*Cervidae*). The use of tree guards generally avoids damage from rabbits and hares, and provides a benign microclimate also. The effects of deer are highly dependent on location, and the eucalyptus species planted. *Eucalyptus* species vary considerably in their palatability, and experience in recent years indicates that *E. glaucescens* is hardly browsed in some locations, despite high deer populations. However

deer seem to particularly like two-year eucalypts for fraying, and young stands of less than 50 eucalypts have been all but destroyed as a result, irrespective of species. Eucalypts seem unaffected by grey squirrels (*Sciurus carolinensis*) or voles (*Microtus* spp.).

Discussion and conclusion

The existence of large eucalypts in many parts of Britain, including some colder areas, indicates that there is potential to grow eucalypts for plantation forestry. Keys to success will include the selection of species and seed provenances appropriate to the location, and suitable establishment and protection to ensure that the risk of damage by cold or by browsing is minimised while the trees are young. This article has highlighted the importance of species and provenance; our following article will discuss the importance of establishment conditions, and the factors influencing yields and wood properties.

The availability of seed is adequate for the current scale of trial planting, although supplies of *E. glaucescens* seed only just cover current demand. However, only *E. nitens* and *E. denticulata* seed is available in quantity from stands of known genetic origin. Bulk seed of other species is likely to be from poorly-described and limited genetic bases; as such, it may not be optimally-adapted to UK conditions. It is quite probable that provenance and progeny trials would identify families and individual trees of superior growth, form and cold-tolerance, as has already been well demonstrated in the trial of *E. subcrenulata* in Haldon Forest, Devon. Such trials could become good sources of seed that is better adapted and more productive than those available at present.

Hybrid *Eucalyptus* may offer further potential, if hybrids can be propagated as rooted cuttings at acceptable cost. This has occurred in many countries with significant industries based on eucalyptus. An opportunity would be to trial the French selections of *E. gunnii* x *dalrympleana* (FCBA, undated), which are likely to perform very well in Britain. Further examples are provided by two hybrids developed by Prima Bio for the ornamental market. One, an *E. gunnii* x *pulverulenta* hybrid, has outstanding form, reasonable rooting ability, good cold tolerance, and an exceptionally high basic density of 600kgm^{-3} at 2 years. A second, an *E. crenulata* x *gunnii* hybrid, has good form and cold tolerance, excellent rooting ability and is not palatable to rabbits and deer. These hybrids demonstrate that there are interesting and unexpected genetic traits within the genus. Such hybrids could be exploited relatively easily, if the demand for them is sufficient to support the necessary development.

The palatability of *Eucalyptus* species to Australian native folivorous mammals has been studied in some detail. The principal compounds that deter feeding appear to be a group of phenolic compounds, the levels of which can vary considerably, even within species (Lawler et. al., 1998; Moore et. al., 2004). There are indications that introduced mammals in Australia, such as rabbits and deer, have similar preferences to native mammalian herbivores (McGlone, undated). If this proves to be the case, then there may be potential to screen and select *Eucalyptus* populations and hybrids in Britain for high levels of unpalatability, as has been done in Australia (Andrew et. al., 2007).

With the uncertainties posed by climate change and new pests and diseases, the prospects of growing trees on much shorter rotations than the norm in Britain presents many attractions. The rapid early growth of eucalypts makes them suited to this application. Planting to date has been on a small scale but there now appears to be sufficient experience to permit provisional selection of species for particular locations.

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