

may be welcomed but rising sea levels will not. Considerable uncertainty exists regarding how coastal zones will be affected, specifically, whether the direction of the Atlantic Current might weaken or change course, making the south west's climate more extreme, prone to storms, intense rains, droughts, and perhaps frosts. Such changes will impact on the whole biological matrix on which our current understanding and policy for agriculture, fisheries, and the countryside depends. Some studies and projections are underway. The scientific community based upon the Universities of Exeter, Plymouth and Cornwall, together with the Eden Foundation, are uniquely placed to study the potential advantages and problems associated with climatic change in the south west so that industry, which includes horticulture and tourism, not only survives but prospers.

Trees and Large Shrubs for Shelter: A Guide to Suitable Species and an Outline of Production Practice[®]

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INTRODUCTION

The problems caused to the horticultural industry by wind-run are well known. In maritime climates the effects are compounded by the inclusion of blown salt particles in the air. The effects range from visible and physiological damage to plants, to financial costs associated with extra labour for standing up blown-over pots, the value of additional fuel used to heat greenhouses and polythene tunnels, and increased irrigation costs due to evaporation. Wind also causes erosion of soil and aids the spread of harmful pathogens.

Work carried out at Rosewarne Experimental Horticultural Station (now Duchy College, Rosewarne) during the 1960s and 1970s demonstrated the benefits of hedges and shelterbelts and set standards for species selection and planting design still followed today. Many shelterbelts planted in the 1960s are coming to the end of their useful life and work is under way on the best means of replacing them. This paper aims to assist anyone planning a new or replacement living shelter by identifying some of the more successful species and providing basic guidance on their production and establishment.

The mild wet winters and cool wet summers typical of maritime climates enable a wide range of high-value horticultural crops to be grown which in turn justifies the use of shelter planting. Such climates also enable a wide range of species to be used for shelter purposes and allows the inclusion of many evergreen species.

PLANNING SHELTERBELTS

The ideal windbreak or shelterbelt gives a wind-filtering effect of approximately 50% and does not act as a solid barrier. Solid barriers create turbulence. Perhaps the most important questions are what is actually required from the shelterbelt and what is actually being protected? If the protection is mainly to enhance yield or prevent physical damage to crops it is vital that the siting does not negate the protective effects, for example by increasing shade or competing for nutrients or water. Where shelter is primarily to protect greenhouses care should be taken to select

species that will not produce too much shade during the winter months and controllable amounts of leaf litter, which can block drains and gutters, during the autumn. Genera such as *Salix* and *Populus* should be avoided where services such as drains are in close proximity as there is a possibility of root penetration into them.

Increasingly shelterbelts and hedges are being recognised as important wildlife habitats. A trial is underway at Rosewarne to examine the range of fauna attracted by different species. Initial results show pines to be virtually "sterile" in terms of the number of species they attract whereas *Escallonia* is highly attractive. Mixed species plantings are far more attractive to wildlife than single-species planting and also more aesthetic to the eye. Both wildlife and aesthetic considerations may be deciding influences in local authority planning decisions. The amount of space available is critical. Small intensive areas such as stock beds or standing-out beds benefit more from low hedges below 3 m tall and these will require on average 3 m of space per row.

Another 3 m is usually needed for maintenance operations such as trimming. Larger field-scale operations, where use of mechanical equipment requires larger open areas, fewer but taller shelterbelts, above 5 m, may be advantageous. It is important to remember that a typical shelterbelt can require as much as 15 m of space per row so consider the benefits of the shelter against loss of production area.

Plans also need to consider neighbouring establishments which may be affected by shade. There may also be the potential problem of "loss of views" in residential areas where consultation with a local authority planning officer may be prudent.

SPECIES SELECTION FOR SHELTERBELTS

The ideal shelter-planting species would be quick growing, produce a dense mass of shoots, not create too much shade, have a non-invasive root system, not produce masses of autumnal leaf litter, and not provide a host for pests and diseases. It should also be available to purchase in sufficient quantities at a realistic price. This might sound impossible to achieve but in fact there are a number of species that fulfil many of the criteria.

Evergreen Species. Pines have often been used to create shelterbelts with *P. radiata* being one of the fastest growing species. This attractive looking plant will attain a height of around 10 m in 25 years under suitable conditions but does create a lot of shade and pine litter. It will occupy a large percentage of production area after a few years and a single row planting 25 years old will require a 20-m-wide strip of land. The root system will also damage adjoining roadways and needs to be kept away from buildings. It is however very salt and wind tolerant. *Pinus nigra* is another good choice being quick growing (10 to 15 m after 25 years) and does not seem to produce so much needle litter. *Pinus pinaster* is similar but not so fast growing, reaching 10 m after 30 years with a more open canopy but much coarser needles. It is more cold tolerant than *P. radiata*.

Another good conifer for shelter is Monterey cypress (*Cupressus macrocarpa*). Its major advantage over pine is that it can be lightly trimmed and makes a good hedge as well as a large tree. The golden form, *C. macrocarpa* 'Donard Gold' and 'Lutea' seem to be even more wind tolerant although it will scorch under extreme conditions.

Before leaving evergreen trees it is worth mentioning the holm oak (*Quercus ilex*). Although regarded as slow growing it has, at Rosewarne, attained a height of 4 m

in 8 years from seed giving a robust, resilient hedge that can be annually trimmed or left if height is required. It is also far hardier than is generally realised although there is considerable genetic variability in seed-raised plants.

Deciduous Species. Suitable deciduous species include *Populus* 'Balsam Spire' an exceedingly fast-growing plant quite capable of attaining 8 m in 4 years at Rosewarne. Here it is grown in conjunction with hybrid *Salix* to give a good hedge of pleasant appearance that is grown as a 4-year-rotation coppice which helps maintain vigour. This also provides valuable habitat to birds such as blue tit and great tit (*Parus caeruleus* and *P. major*) both of which are major predators of aphids. Blackbird (*Turdus merula*) and song thrush (*T. philomelos*) also nest in this hedge. *Populus alba* is an excellent choice for very exposed situations as it is salt tolerant. This is not so vigorous as other species of poplar but is attractive with its silver foliage and rounded habit. Other species of *Populus* are not so successful in maritime or humid climates due to an apparently greater susceptibility to bacterial canker (*Xanthomonas populi*).

Two of the most successful species of deciduous tree suitable for shelterbelts at Rosewarne have been the Italian alder (*Alnus cordata*) and red alder (*A. rubra*). As a combination planting, these have grown to 10 m in less than 8 years and have proven very resilient to wind and pests. They tend to leaf-up early and retain their foliage late into the season, thus giving a long period of protection. They are also attractive and make a useful contribution to the landscape. Another underrated and perhaps surprisingly successful shelter tree is the sweet chestnut (*Castanea sativa*). Being slow in growth (10 m after 25 years) this is a longer-term selection but is worth including to give longevity to plantings and of course it can be coppiced if needed. One of the most successful native species is common ash (*Fraxinus excelsior*). Fast growing and not producing too dense a canopy, ash is particularly good in exposed coastal areas.

SPECIES SELECTION FOR SHELTER HEDGES

Unless able to designate large areas of land to shelterbelt planting, many horticultural establishments will opt for protection using hedges. These are more attractive than artificial breaks, last longer, but take time to establish and provide protection.

Evergreens provide year-round shelter but need to be cold and salt resistant to be worth considering. The southern hemisphere has always provided some very valuable species that are perfectly suited for shelter purposes. The genus *Olearia* (daisy bushes) gives us at least three choices. *Olearia macrodonta* (New Zealand holly) is an extremely tough evergreen growing to 4 m after 15 years. The large silvery-grey leaves are complimented by the white flowers that almost hide the plant. This plant needs little trimming and is hardy down to -10°C. *Olearia traversii* is a fast-growing (3 m after 5 years) attractive plant suitable for coastal areas. This plant trims well but is only hardy down to -6°C, however it is worth considering for its fast growth rate and attractiveness and could be used in mixed plantings with hardier species. Another fast-growing (4 m after 6 years) plant is *O. virgata* 'Dartonii'. This forms a very upright plant that filters wind well but creates little shade and is used extensively in parts of Brittany. It is hardy to -8°C.

In colder districts, *Escallonia* is an excellent choice with *E. rubra* 'Crimson Spire' withstanding -15°C. Combined with a pleasant appearance and red flowers (that according to bee keepers produces good quality honey) it is probably the most ver-

satellite of the traditional hedging subjects — its only negative point being the need to trim regularly in order to maintain its shape. *Escallonia rubra* var. *macrantha* is not seen as often as *E. rubra* 'Crimson Spire' due to limited production on nurseries. This is a pity for it is potentially a more manageable plant in the longer term with little need to trim. It is a more attractive plant with dark glossy green foliage and should be better known. Both of the *Escallonias* mentioned have good environmental credentials and apart from the nectar being used by honey bees, a wide variety of birds use them for nesting. They are also virtually free from pests and diseases making them ideal on stock beds for hardy ornamental nursery stock. Other good *Escallonias* include *E. rubra* 'Ingramii' and *E. xexoniensis*.

The genus *Elaeagnus* contains several species and hybrids suitable as vigorous shelter hedges in cold and maritime districts. The hybrid *E. xebbingei* makes an effective barrier but may be too vigorous unless trimmed regularly. It can make a shelter hedge 6 m high and 7 m across after 15 years but does respond well to hard trimming and can be pollarded if needed. Its large silver-grey foliage and scented flowers make it a popular choice and it is readily obtainable. Another good, if less readily available *Elaeagnus* is *E. macrophylla* with silver foliage and less vigour. This has also proven useful as a source of cut foliage used by local florists generating a small but useful income.

Lastly two plants that have been tried at Rosewarne recently and have provided excellent "seasonal" protection during late summer and winter are pampas grass (*Cortaderia selloana*) and elephant grass (*Miscanthus sacchariflorus*), the latter being grown as a bio-fuel. Both of these herbaceous perennials have proven durable and free from major pests and diseases. They need little or no management and provide a dense screen growing to approximately 2 to 3 m in height. The pampas retains its foliage through the winter months whereas the *Miscanthus* loses its foliage but retains a dense crop of woody "canes". Both are worth trying on very exposed sites where low-level protection is desirable, such as for outdoor cut-flower production or salad crops.

PRODUCTION OF PLANTS FOR SHELTER PURPOSES

Producing a strong well developed root system that is able to support the plant in its exposed situation is particularly important. Two methods can be used to ensure the root system develops a suitable framework that will anchor the plant and provide long-term and trouble-free shelter.

Direct Sticking of Cuttings in Situ. This has proven to be an extremely successful method of establishing shelter hedges using hardwood evergreen cuttings taken during November. It produces quick results and is useful in maritime districts and particularly exposed situations where container-grown plants would need to be staked carefully.

After the chosen site has been cleared of all perennial weeds and the ground prepared by deep cultivation and then levelled, black 600-gauge polythene or woven polypropylene is pegged down, or preferably slotted into the ground using a spade or mechanical means and prepared cuttings are pushed through into the underlying soil. Typical cuttings need to be at least 25 cm in length with all but the top two or three sets of leaves removed. Cuttings are inserted to 80% of their length to prevent wind-rock. With *Escallonia* and *Olearia* a minimum of 90% rooting is expected using this method and it is possible with *E. rubra* 'Crimson Spire' to have a hedge 1 m high in 1 year. As transplanting is eliminated this is a very cost-effective method of establishing a strong hedge. Importantly the root system develops under exposed

conditions and wind-rock is virtually absent. This method can also be successfully used for *Populus* 'Balsam Spire', *P. alba*, and *Salix viminalis* hybrids.

Container-grown Shelter Hedging. Production of container-grown hedging plants is similar to that for all container-grown nursery stock except that plants grown outdoors have proven to be far more robust and less susceptible to wind-rock than those grown under polythene or glass. Defoliation of plants grown under protection and planted into exposed sites has also been observed at Rosewarne. Plants should not be pot-bound and smaller plants appear to establish more successfully.

Tree species that resent root disturbance and need to be grown from seed, such as *Pinus radiata*, are best grown in ribbed containers such as Roottrainers that ensure roots do not become coiled. Observations based on re-planting at Rosewarne have indicated that all tree species, pines in particular, establish best if planted as small, typically 15- to 30-cm, seedlings. These plants seem to develop strong lateral root systems and even tap roots that are vital to ensure successful establishment. Never be tempted to produce or plant larger, pot-bound plants that are difficult to establish and may require long-term staking.

It is important with pines to ensure that their provenance is known. Many pines are raised from seeds collected commercially from trees grown under forestry conditions and these are often selected for vigour and productivity. These are qualities not suitable for exposed sites and poor establishment can result with particular problems of wind-throw of young plants. This has been observed as a recent problem on St. Marys, Isles of Scilly. Where smaller numbers are required there may be a case for collecting seed from local, proven trees growing under similar conditions. This is certainly within the ability of most growers and is not necessarily very time consuming. All recent replantings at Rosewarne have come from seed collected either on site or locally.

Bare-root plants should also be grown from known provenance seed or locally sourced cutting material where possible, and undercut to ensure lateral root development so vital for transplanted plants. There is no available evidence to suggest whether plants are best produced as container or bare-root for windbreak purposes. However initial root system formation is absolutely crucial to long-term success whichever method is used.

PRE-PLANTING AND POST-PLANTING MANAGEMENT

Any site should be suitable for the intended species to be grown. Most species used for shelterbelts and shelter hedges tend not to have exacting soil requirements although it is important to consider drainage and soil depth. Shelterbelts are long-term propositions and shallow soils may not support subsequent top growth. It is always worth checking to see which species occur and thrive locally and base your choice on these. Evergreen species such as *Pinus radiata* tend not to thrive on wet sites and conversely growth may be poor on dry shallow soils. *Alnus* or *Fraxinus* are best on these sites. Wet or partly shady sites are also liked by *Alnus* but it is not likely that shelterbelts will establish successfully in deep shade. Site preparation is the most important factor in establishment of shelterbelts. If possible the site should be sub-soiled and cultivated as deeply as is possible — around 45 cm is ideal — without bringing sub-soil to the surface. Root penetration vertically as well as laterally is desirable. Failing this, hand cultivation of each planting hole should aim to achieve similar results by creating a "rooting zone" around the plant, whether container grown or bare root. This needs to be at least 25 cm greater than the existing root system.

Perennial weed growth must be removed prior to planting. This is best achieved by spraying with a translocated herbicide such as glyphosate 6 weeks before planting. For bare-root deciduous species planting is best carried out during November to January when weather and ground conditions permit.

Container-grown or evergreen species are traditionally planted at the same time although it may be beneficial to wait until March or April on very exposed sites in order to prevent damage. This gives the plants 6 months to establish themselves before the onset of winter gales and rain. It is important to consider that even the most wind-hardy plants need initial protection in order to aid establishment. Staking is essential but if trees are planted at a maximum of 45 cm tall for deciduous species and 30 cm tall for evergreen species this can be kept to simple canes and ties.

Trees should be staked securely but with flexibility to move with wind movement. Observations at Rosewarne have shown that plants with short stakes that are able to move develop stronger stems than those that rely on their supports. This is an important consideration in establishing shelterbelts. Trees that are reliant on their stakes are far less likely to succeed than those that can flex. Reject container grown trees that appear loose in their pots and those that are pot-bound.

The addition of a general base dressing is beneficial at planting time as is the use of a soil conditioning compost. Planting distances vary from species to species. It is however beneficial to plant at a greater density than the desired final spacing with periodic thinning as required. The use of short-term “nursery plantings” — quicker growing species that give initial protection to slower growing species but are then removed after a period of time — has proven useful in recent re-plantings at Rosewarne. Examples include fast-growing *Salix* or *Alnus cordata* used to protect *Fraxinus excelsior* or *Quercus ilex* for the first 3 to 5 years. Thinning in these situations is a vital part of post-planting management and should not be ignored. Typical spacing for *Pinus* at planting is 3 m and for *Alnus* 2 m. As with hedges, planting in staggered rows in a “W” fashion is preferable but takes up more valuable cropping area. These are thinned after 3 to 5 years and potentially again at 15 to 20 years. Un-thinned trees tend to become etiolated and lose effective wind-filtering potential. This is particularly the case with evergreens.

The use of tree shelters or guards is of mixed benefit. Solid types such as those made of corrugated plastic give good initial protection against the effects of wind but should be viewed as short term and removed after 1 or 2 years otherwise plants tend to become “leggy” and top-heavy. Weed growth within the shelter can compete with the crop for nutrient and light. Solid shelters are used at Rosewarne for evergreen species and the mesh type for deciduous species. Both types should be used in conjunction with weed suppressant mats and/or appropriate residual herbicides to gain the maximum benefit. Unless used as an establishment tool with a view to removing after a short period of time, the effects of shelters can be detrimental and can be a major cause of post-planting failure. Longer-term management must include thinning and replacement planting as required.

To remain effective, annual trimming is recommended for most evergreen shelter hedges. Flailing is an effective method leaving little residue to remove but should be carried-out during late summer or early spring. Care should be taken not to cut during the nesting season.

A well planned and maintained shelterbelt or shelter hedge should require little input in terms of labour and cost but provide many years of service.