Introduction

The primary purpose of farm shelter is to protect livestock, pasture and crops from the wind. Strong wind causes physiological stress in plants and animals. Plants' transpiration increases, desiccating pasture or cropland and stunting its growth. A greater proportion of animals' metabolism is diverted into maintaining body temperature instead of weight gain. Good shelter will reduce stress. Scientific trials confirm what many farmers observe after establishing shelter:

- Dry matter production increases between 5 and 15%,
- Less stress on livestock, better metabolic conversion of feed, and faster weight gain.

Shelter can also be multiple-purpose. A shelterbelt can often be planted in a retired riparian margin. Where soils are subject to wind erosion, for instance coastal sand country, shelterbelts can reduce soil loss. Using commercial timber species for farm shelter creates the prospect of additional farm income. Shelter provides habitat for birds, which reduce insect pests in pasture and cropland. Shelter trees also enhance the farm landscape.

General principles

Height, length and their effect on wind reduction

The area protected downwind of the belt is proportional to its height (Figure 1). Typical field data suggests a good shelterbelt will have a 30% to 50% reduction in wind velocity up to 10 times its height (10H) and a 10% to 20% reduction up to 20H. There is a reduction in wind speed of 50 to 80% from 1-5H downwind of the belt.

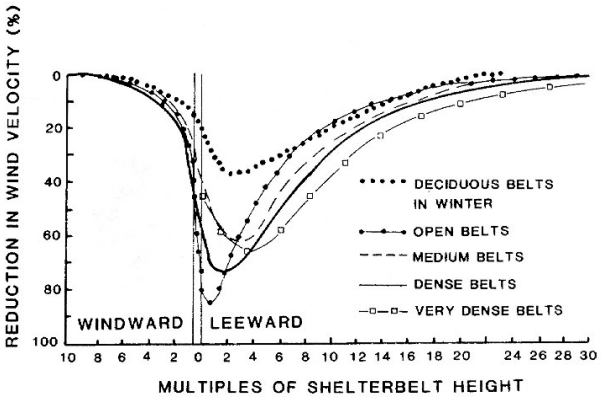


Figure 1: *Patterns of wind abatement in the vicinity of shelterbelts of different density (after Carbon 1965)*

For maximum area protected, a continuous length at least 24 times the ultimate height of the windbreak is desirable. Where continuity is not possible, individual windbreak segments' length should be at least 12 times the height of the shelter trees.

Permeability

The eddying wind flow behind a shelterbelt varies greatly depending on the density of the belt. When wind hits an impermeable barrier, it is forced up and over, reducing its speed and creating turbulence on the other side, before it carries on and regains normal velocity. This turbulence created on the leeward side is more damaging than a straight wind. Some turbulence is also created on the windward side.

Therefore, a semi-permeable barrier works best. It has approximately 40-60% porosity (air passage), so acts as a wind filter rather than a barrier, and provides the maximum area of protection out into the paddock. Appropriate spacings between trees, as in Figures 2 to 5, and proper management such as pruning and trimming, help to achieve good permeability.

Uniformity

Shelter should be maintained down to ground level as bottom draughts can create wind funnelling. Trimming encourages foliage growth to ground level in a number of species. Alternatively, a lower-growing species can be planted windward of a taller species to prevent bottom draughts, particularly if it is intended the taller species be pruned. To avoid any gaps where wind may funnel through, 100% survival of trees in the belt is required. Blanking (replacing dead

trees) may be necessary in the season after planting to ensure even growth of the belt.

Designing a shelterbelt

Types of shelter

Proper design and layout of shelterbelts is important if they are to perform properly. A number of designs can achieve the criteria for any one effective windbreak. Final choice will depend on the severity of weather conditions, availability of space, financial resources, and personal preference: *Single row shelterbelts minimise loss of productive land, but require a high standard of planting and aftercare, to ensure uniformity of height and density*.

The fast-growing species in Figure 3 provides quick shelter for the first few years, and can be harvested for firewood or timber once the slow-growing species reaches an acceptable height. However, it may be hard to maintain an acceptable density after removing the dual-purpose trees.

Double row shelterbelts help achieve effective shelter quicker than planting complementary low-growing and high-growing species in a single row. A suitable low-growing species is usually evergreen, and maintains branches to ground level without sprawling. Planted as the windward row, it shelters tall-growing species in the leeward row while they establish. This design is particularly suitable for boundary shelter as well as other situations where it's important to get height quickly and also retain density lower down in the long term.

The windward slow-growing shelter species in Figure 5 provides permanent shelter, the same as the low-growing species in Figure 4. The slow-growing shelter species, (eg. Japanese cedar), should retain branches to ground level to provide effective shelter. The leeward fast-growing timber species, (eg. radiata pine), can be pruned and later harvested for firewood or timber, while the slower growing species remains as effective shelter, and can also possibly be harvested at maturity.

Choice of species

For effective establishment of shelter, it is essential that the species chosen are adapted to the local environment. It is not worth persevering with species that do not grow well in a particular location.

Both deciduous and evergreen trees can be planted for shelter. Either type can be used alone, or in combination with the other. Evergreen species are preferable where year-round shelter or shelter from prevailing wind is required. Deciduous species can complement evergreen species, especially for internal shelter or reduced winter shading. A benefit of deciduous shelter is its higher resistance to wind damage by winter gales, as air passes more easily through the trees after leaves have fallen.

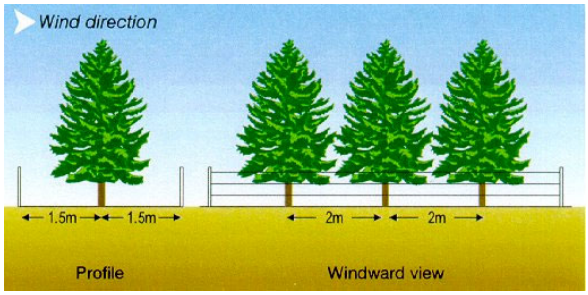


Figure 2: *Single row, single species.*

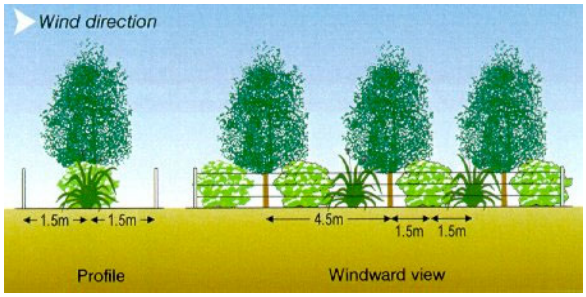


Figure 3*: Single row, interplanted with faster higher growing dual-purpose species.*

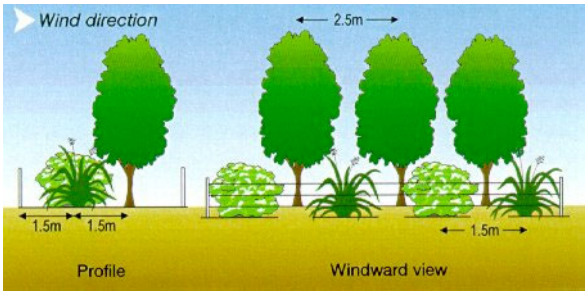


Figure 4: *Double row with low-growing species windward and taller species leeward.*

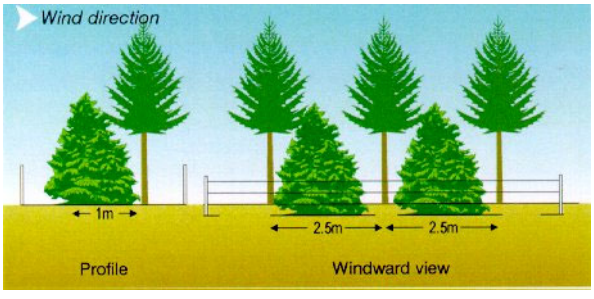


Figure 5*: Double row with slow-growing permanent shelter species windward and faster-growing timber species leeward.*

Species commonly used for farm shelter in Taranaki are:

Common name	Botanical name
Evergreen	
Radiata pine	*Pinus radiata*
Bishop pine	*Pinus muricata*
Norfolk pine	*Araucaria heterophylla*
Japanese cedar	*Cryptomeria japonica*
Macrocarpa	*Cupressus macrocarpa*
Lawson cypress	*Cupressus lawsoniana*
Leyland cypress	*Cupressocyparis leylandii*
Mountain ash	*Eucalyptus fraxinoides*
Shining gum	*Eucalyptus nitens*
Coastal banksia	*Banksia integrifolia*
Swamp sheoke	*Casuarina glauca*
Deciduous	
Tasman poplar	*Populus deltoides x P.nigra*
Crows nest poplar	*(P.deltoides x P.nigra) x.P.nigra.*
Tangoio willow	*Salix matsudana x alba* 'Tangoio'
Moutere willow	*Salix matsudana x alba* 'Moutere'
Matsudana	*Salix matsudana x alba*
Native	
Lemonwood	*Pittosporum eugenioides*
Kohuhu	*Pittosporum tenuifolium*
Karo	*Pittosporum crassifolium*
Korokio	*Corokia macrocarpa*
Broadleaf	*Griselinia littoralis*
Pohutukawa	*Metrosideros excelsa*
Ngaio	*Myoporum laetum*
Akeake	*Dodonea viscosa*
Golden akeake	*Olearia albida/angulata*
Chatham akeake	*Olearia traversii*
Akiraho	*Olearia paniculata*
Koromiko	*Hebe stricta*
Flax	*Phormium tenax*
Toetoe	*Cortaderia fulvida*
Cabbage tree	*Cordyline australis*

It is worth consulting local nurseries, farm forestry groups, or Land Management Officers at the Taranaki Regional Council; all of whom can offer advice about species' suitability for a particular site. However, final choice always remains at the discretion of the landowner. Apart from design considerations already outlined, it will also depend on the price and availability of planting stock, financial resources, and personal preference or dislike for a particular species.

Existing native vegetation can often be retained (or its reversion encouraged), to provide complementary lower-tier shelter windward of exotic trees. The available options should be considered carefully. Well-selected and managed shelterbelts can be expected to survive for 25 to 50 years.

Layout of plantings

Shelterbelt placement usually depends on the direction of prevailing winds, issues associated with shading, and terrain.

A shelterbelt should ideally be placed at right angles to the prevailing wind, to achieve maximum effect. Rather than re-align paddock boundaries, it is more practical to plant along existing fences so long as they are at an angle greater than 45 degrees.

If minimisation of shading is important, shelterbelts should be oriented in a north - south direction. By doing so, all paddocks will be exposed to some sun through the day as it moves from east to west. Where this is not possible, planting deciduous species in a east-west orientation will ensure shading is minimised in winter, while simultaneously breaking wind.

Blending with terrain

On rolling or hilly ground, greater downwind shelter can be achieved by planting shelterbelts along ridges. A disadvantage of this practice is that it exposes trees to greater damage by gales, making it hard to maintain a uniform shelterbelt long-term.

Landscaping is also a factor some farmers consider important. If shelter can be aligned with natural breaks in slope e.g. a fence along a slope-foot, a spur, a streambank or gully edge, it can be more pleasing to the eye than a line of trees running across-slope at an odd angle.

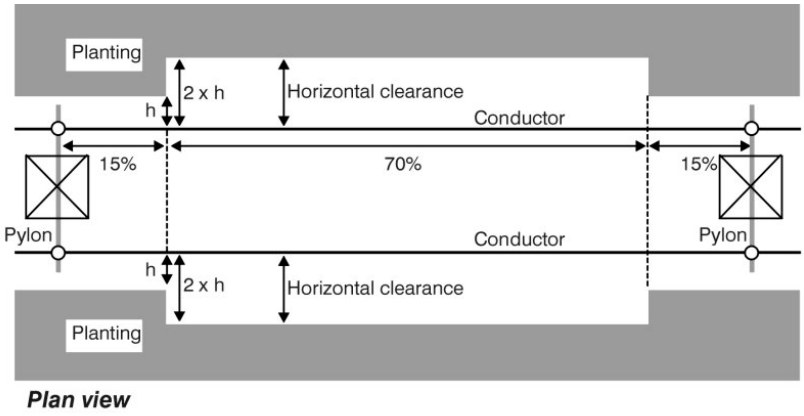
Neighbours

Planting tall evergreen shelter along a boundary is likely to disadvantage neighbours, therefore some discussion should take place prior to planting, to avoid disagreement at a later date. District Councils in the Taranaki Region are moving to protect the rights of adjoining landholders, by writing rules into district plans that place a height restriction on boundary shelter, or control how close to the boundary a shelterbelt may be planted. It is a good idea to check with the local District Council, before planting along boundaries.

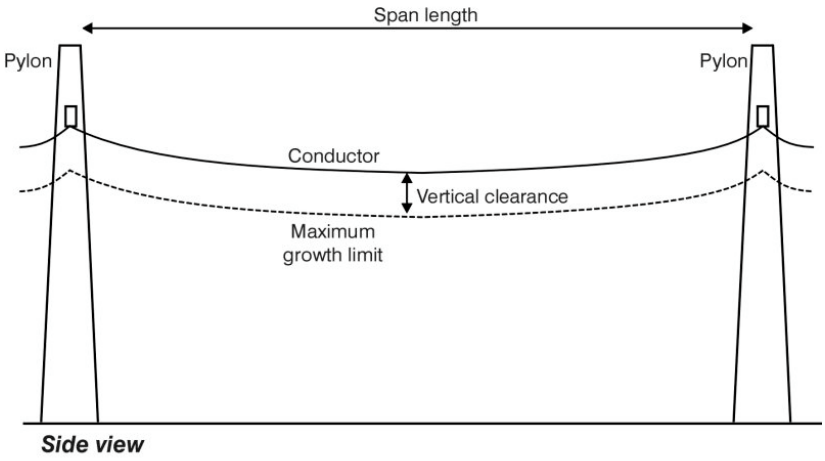
Power lines

Where gaps for pylons and overhead power lines are unavoidable, the following recommendations are provided from Transpower (Figure 6):

- Make sure there is at least a 4 metre clearance below conductors
- 4 metres is the minimum distance from the line before trimming is required. Therefore, 6 metres is ideal
- Trees should be at least 15 metres to the side of conductors in the mid 70% of a 300 metre span
- In Taranaki, tree trimming and maintenance around Transpower lines is contracted to Electrix Ltd. For more information and advice, contact Electrix Ltd at Stratford on 06.7655494



Plan view



Side view

Span length (metres)	150-300m	300-500m	500-750m	over 750m
Vertical clearance (metres)	3.5	4	4	4
Horizontal clearance (metres) (first 15%)	4	7.5	15	25
Horizontal clearance (metres) (centre 70%)	8	15	30	50

Figure 6: *Shelterbelt growth limits and clearance from high voltage power lines and pylons, with spans over 150 metres.*

Other hazards

Civil aviation regulations prohibit the planting of trees in positions which obstruct commercial airfield flight paths. Similar care should be taken, if shelterbelts are proposed in the vicinity of a farm airstrip. Tranzrail's approval is needed before planting shelterbelts alongside railway lines.

There are no regulations which restrict tree-planting on private land adjacent to a road, but it is a good idea to consider whether a roadside shelterbelt may restrict traffic visibility in years to come, or prolong winter ice in its shadow.

Establishing shelter

Fencing

Shelterbelts must be completely stockproof - this cannot be stressed enough. Stock browsing can severely set back growth of seedlings, cause malformation in subsequent growth, or even destroy seedlings. Consequently, fencing must be completed before tree establishment. Specific criteria for shelter fences are:

- The distance from tree to fence should be 1 metre for sheep, 2 metres for cattle, and even greater for horses,
- To avoid shorting of electrified fences, regularly spray beneath them and check that no small branches are touching them.

Cost of fencing can be kept down by utilising an existing fence along one side of the proposed shelterbelt. For the new fence on its other side,

low-cost fence designs may be suitable e.g. a two or three-wire electric fence would be adequate on dairy farms. The Council's information sheet *Riparian Fences* describes several low-cost designs.

Pre-plant weed control

Weeds must be eliminated to remove competition with the trees for light, nutrients and moisture. Good weed control in the establishment phase is essential; not only does it increase survival, it also promotes early tree growth.

A wide variety of sprays is available; which one is right for the job, depends on the weeds present and what trees are being established. If unsure, ask a Land Management Officer for advice. Sprays used can be either knock-down or residual. A good broad-spectrum knock-down spray, such as Roundup, can be used on existing vegetation up to three weeks before planting; a dye can be added to mark the sprayed areas. A residual herbicide such as Foresite 380 can provide up to three months' weed control; however it must be applied to bare soil, therefore knockdown herbicides must be applied well in advance to allow sprayed vegetation to rot away.

Pre-plant sprays can either be applied as strips or spots. Spots should be at least one metre in diameter, and should be accurately marked out according to the shelter design. Alternatively, strips 1.4 metres in width can be used per row of trees.

Planting

Trees should be ordered well in advance of planting, so that good quality seedlings of the required species are obtained and can be planted on time.

The handling time between nursery and planting site should be kept to a minimum. At all times seedlings must be kept cool and sheltered. The roots should not become dry at any time and must be handled carefully to avoid physical damage to fine root hairs. If bare-rooted stock is to be kept for more than two to three days before planting, seedlings should be carefully heeled in (to moist sawdust) and watered regularly.

On fertile sites, plant in late winter or early spring - trees planted early in winter may grow too fast and become prone to toppling. They may also be damaged by frost (unlikely with exotic species used for shelter, but a risk with natives). On infertile or dry sites e.g. sand dunes, it may be better to risk planting early in winter, so that trees are well established before a drought arrives the following summer.

When planting, the best tool is a tree-planting spade designed specifically for the job. "Cultivation" of planting spots is essential for good root placement. It allows roots to penetrate laterally for nutrition and vertically for anchorage:

- Dig the spade in a full spade-depth, and "cultivate" the soil by wiggling it back and forth. This creates a planting hole that is wide enough to take the roots.
- Place the seedling's roots in the bottom of the hole, and replace earth around them.
- Pull the seedling up through the fill about 10 centimetres, to ensure roots are straight and foliage is clear.
- Continue to hold the top of the seedling after pull-up, and firm the soil around the stem with the sole of your boot.

Release-weeding

Releasing is one of the most critical factors associated with successful plant establishment. It is essential to release plants during their first growing season, so competition by weeds and grass for moisture, nutrients and light is eliminated. Failure to do so may result in stunted growth, uneven establishment, smothering, or even death.

The timing is dictated by regrowth of the weeds, but is generally needed within twelve months; and soon after planting, if only a knock-down pre-plant herbicide was used. Further releasing may be needed depending on the growth rate of the plants. At least two years is usual; several years longer if the species is slow-growing.

If possible, all weeds should be controlled before reaching ten centimetres height, either by spraying or handweeding. Where vegetation does become rank, hand-grubbing or line-trimming should be carried out prior.

When spraying, avoid the seedling's stem and foliage. It is a good idea to cover it with an old plastic container or pipe; spray can then be applied to within a few centimetres while avoiding any contact.

Blanking

Blanking refers to the replacement of plants that do not survive. It is best carried out after the first growing season, so that differences in shelter growth are small. Purchasing healthy plants, correct planting technique, ensuring stock are excluded, and timely release spraying, all help reduce the need for blanking.

Pruning

Lateral spread of branches and porosity of the shelterbelt can be controlled by trimming or pruning. Aim for a porosity of 40-50%, to ensure maximum leeside protection. Trimming or pruning are also advisable to prevent trees from overhanging fencelines, as this can encourage stock to camp underneath.

Animal pests

Rabbits and hares can cause considerable damage. Controlling these pests before planting is desirable. Hares can be spot-lighted and night-shot; rabbits can be shot or poisoned.

Possums are capable of causing considerable damage to established shelterbelts, and spread bovine tuberculosis. For both reasons, regular shooting, trapping, or poisoning will be needed. Animal repellent can help protect seedlings.

For information sheets about these topics, contact the Council's Pest Management Officers, who can provide further assistance if needed.

Timberbelts

Single row timberbelts are a way to obtain a cash return from shelter in future years (Figure 7). At 2.5 m spacings between trees and pruned to at least 6.5 metres, pine timberbelts are expected to return at least $15-25,000 per kilometre (based on 2002 average price for P1 logs delivered to mill). Second-grade logs may also provide some return, even though branches are expected to be large due to their open-grown habit. Other high-value species e.g. cypresses are worth considering; as are eucalypts which do not require as much silviculture.

On fertile farm sites that are exposed to wind, 4 to 5 year old physiologically aged cuttings are recommended for pine timberbelts. Compared to seedlings, older cuttings are woodier, have a more rigid root system, do not have such bushy crowns and tend to produce a single terminal leader. These traits provide better wind tolerance and growth on fertile farm sites.

Pines in narrow timber belts have faster growth rates than pines in a forest. Timing of operations is therefore less flexible, if good timber is to be achieved. Check timberbelts regularly:

- Assess growth and stem diameter to predict pruning times,
- Look for things that need treating - possum damage, disease, change in growth, form or needle colour, and weeds.

Timberbelts are easier to prune than woodlots, because they have fewer trees and the trees are easily accessed. However, their open growth form necessitates greater care when pruning, and more attention to timing. Pruning correctly and on time is critical to achieving high quality timber. Refer to the Council's information sheets on **Radiata Pine Woodlots** for details of when and how to prune. If unsure, use a qualified forestry consultant to help with final decisions.

Timberbelts should not be thinned, as this destroys their value for farm shelter. Plant trees at their final spacing - about 2.5 to 5 metres - and use second tier shelter to block the gaps between.

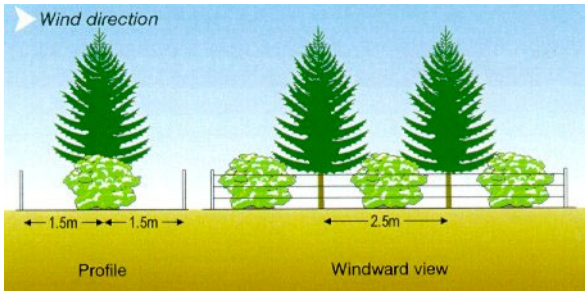


Figure 7: Single row timberbelt with planted native understory for low shelter.

The Taranaki Regional Council can provide advice and assistance with design of shelterbelts and timberbelts, as part of a farm conservation plan.

For further advice or information, contact:

The Land Management Section,

Taranaki Regional Council

Private Bag 713, Stratford

Ph: 06 765 7127

www.taranakiplants.net.nz