

THE ECONOMIC BENEFITS OF NATIVE SHELTER BELTS REPORT

Issue 3/2015



SUMMARY



Typical shelterbelt utilising existing fence lines.
Source: DPI Victoria (2009).

The protection of existing native vegetation and the planting of shelterbelts may provide a multitude of productivity and biodiversity benefits for farming industries. The value of shelterbelts in raising agricultural productivity has been demonstrated in many countries suggesting potential improvements in crop yields (25%), pasture yields (20-30%), and dairy milk production (10-20%).¹

The following information is based on references and previous research, providing examples of existing 'facts and figures' when considering the economic benefits of implementing shelterbelts. Productivity increases relate to all agricultural industry sectors, including the dairy, wool, meat, cropping, and horticultural industries.

Farmers can use this information to more effectively utilise the landscape to potentially increase productivity, while conserving and enhancing critical resources such as soil health, water quality, and protection from environmental stressors (wind, heat & cold impacts).



Multiple configurations of shelterbelts at Curdievale (SW Victoria), providing stock and pasture protection from various wind directions. Source: Quickbird USA (2008).

Shelterbelts with strategic placement and well-defined objectives have numerous potential benefits to farm productivity such as:

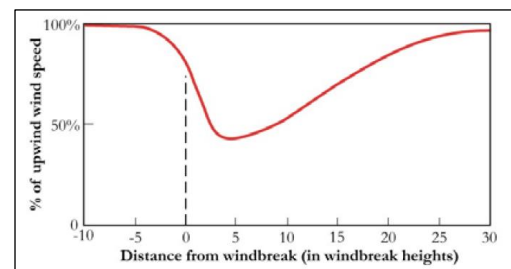
- Protect crops and pastures from drying winds
- Protect livestock from cold or hot winds
- Provision of shade to protect stock from the effects of heat stress in summer as 'extreme' heat years increase²
- Provide habitat for wildlife and natural biological control agents
- Help prevent salinity and soil erosion
- Conservation of soil water, extending the growing season (pasture) and reducing soil erosion and nutrient loss.

- Boundary shelter/windbreaks can reduce bio-security hazards to stock from neighbouring land³ (eg. prevent nose-to-nose contact, weed movement control)
- Provide posts, firewood, timber, fodder, honey, bush foods, nuts, cork and various other products
- Protect and enhance living and working areas
- Acts as a firebreak
- Increase medium to long-term land values⁴

HOW SHELTERBELTS WORK

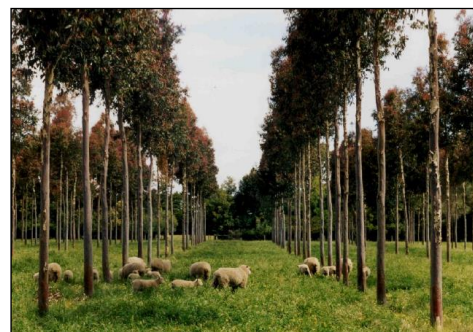
Permeable shelterbelts of trees and shrubs work by filtering and breaking the force of the wind, allowing slight air movement through the shelterbelt and create less turbulence on the windward side. Numerous research has shown dense windbreaks (<30% porosity) provide increased protection downwind of a well-designed windbreak or shelterbelt however tend to have increased turbulence on the windward side of shelterbelts.

The differences in air pressure on the windward and leeward sides of the shelterbelt provide the protection,⁵ forming a 'cushion' of slow moving air.⁶



Impact of wind speed reductions and distance from windbreak.
Source: Rowan Reid (University of Melbourne) (2013).

- The shelterbelt/windbreak height determines the size of sheltered area, with taller trees protecting a greater area. The tallest tree species should form the backbone if shelter is the primary objective.
- Wind deflected around the ends of windbreaks increases turbulence and reduces shelter effect, therefore windbreaks/shelterbelts should be long and continuous, to minimise end-effects.⁷ A grid of shelterbelts offers best protection from all winds.



Multiple use agroforestry, wool growing and shelterbelt system.
(Source: Bird 1996).



Multi-layered windbreak to reduce wind tunnelling effects.
Source: Agriculture WA (2012).

ADAPTING TO A CHANGING CLIMATE

Even though continually disputed, the evidence is clear of an increasing warming climate trend⁸ and increases in extreme weather events. The analysis⁹ shows that the extent and frequency of exceptionally hot years have been increasing rapidly over recent decades, and that trend is expected to continue.

This research suggests further that on average, exceptionally high temperatures are likely to occur every one to two years, or for the last 100 years, the hottest five years are what we can expect every one to two years (2010-2030). Effective farm shelter can assist in protecting farm animals, paddocks, plants and soils from such increasing extreme events.

Numerous studies suggest heat stress can markedly reduce stock fertility, milk production and weight gain, and increase mortality of calves and sheep. Effects of heat also may cause abortion and certainly causes calves to be born undersized and consequently more susceptible to heat stress.¹⁰

OUR COLLECTIVE RESPONSIBILITY TO REDUCE CARBON IN THE ATMOSPHERE

Agriculture produces approximately 10-12% of total greenhouse gas emissions. At 16% it is the second largest contributor to Australia's total emissions and would therefore be expected to be part of strategies to reduce national emissions. Main sources of greenhouse gases from agriculture include methane (rumen digestion) and nitrous oxide (nitrogen fertilisers).¹¹

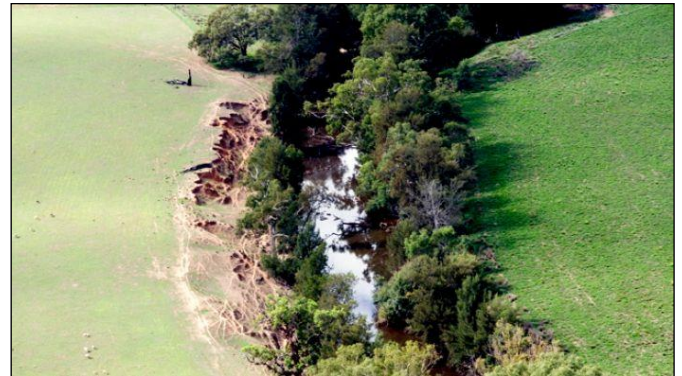
Planting trees to offset total net emissions for the dairy farm is practically impossible nevertheless the integration of trees should not be disregarded. However with sheep farming increasing plantings has the potential to offset a portion of the farm's emissions.

The goal of agricultural carbon removal is to use the crop and it's carbon cycle to permanently sequester carbon within the soil and is done by selecting farming methods that return biomass to the soil and enhance the conditions in which the carbon within plants is reduced to its elemental nature and stored in a stable state. Shelterbelts enhance the conditions that support some of these methods which include:

- Use of cover crops such as grasses and weeds as temporary cover between planting seasons.
- Concentrate livestock and graze paddocks lightly but evenly which encourages deeper root growth of pasture.
- Cover bare paddocks with hay or dead vegetation protecting the soil from the sun, allowing increased soil

moisture which is more attractive to carbon-capturing microbes.

- Restore degraded land which slows carbon release.
- Agricultural sequestration practices have positive effects on soil, air, and water quality, are beneficial to wildlife, and can expand food production.
- The added benefit of these solutions is the potential for simultaneous enhancement in agricultural production.¹²



A stark comparison of different grazing regimes, one which is building soil carbon stores, and one which isn't. (Source: ABC Australia 2014)

FUTURE MARKETS, QUALITY ASSURANCE, ANIMAL WELFARE

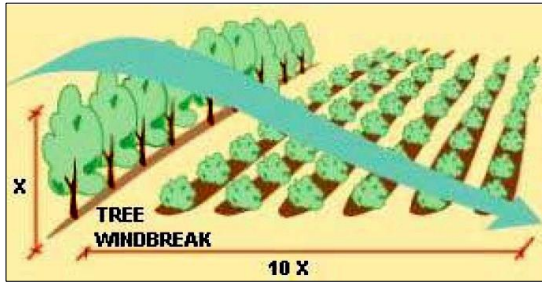
The dairy industry will continue to improve the level of production and efficiency of production in order to remain viable. However, this must be done in a way that does not compromise long-term sustainability of farming, or produce manifestly adverse off-site impacts on the environment.

In addition, future developments should produce improvements to already seriously depleted biodiversity in the dairy regions and in animal welfare issues. Pollution of the waterways and groundwater, loss of biodiversity, loss of traditional landscape appeal, increasing concern for animal welfare have created a massive change in outlook of society in general.

Countries such as The Netherlands have embarked upon a reorientation of farming systems in order to find a new balance between economic goals and rural employment, and care for clean water and air, animal well-being, safe food, and the preservation of soil, landscape and biodiversity.

Changing community and government perceptions will have an increasing influence on Australian dairying. Sustainable land management was embedded in New Zealand law in the form of the Resource Management Act, 1991.

Phil Keegan a dairy farmer in SW Victorian dairy for 30 years believes there is a 'duty of care' to the stock that we care for and on his farm he has actively worked to increase the amount of protection in the form of native shelter over 30 years. He believes in further promotion of farms that have utilised a whole farm plan, and that have a strong emphasis on native plantations and environment considerations for animals in one's care.¹³



Protection zone principles.
Source: Goolwa/Wellington LAP SA (2012).

Phil also suggests the future will be influenced by quality assurance programs as practiced in NZ for the last 20 years which gain lucrative market advantage globally with their 'clean & green' marketing tool to increase awareness to international buyers that they are working with their farmers to produce a low environmental impact product; something the purchaser and end product user wants to hear.

Increases in consumer demand for organic products and those with environmental and animal ethics quality assurance credentials are changing the face of the local and export agricultural market.

Providing shelter and moving stock to adequate shelter is a moral responsibility which is implicit in the 'five freedoms' described by the Animal Welfare Advisory Committee of New Zealand and in general it is difficult to argue that it is a responsibility which either imposes unreasonable costs or is unrealistic to achieve.¹⁴

THE OLD ARGUMENT – THE BENEFITS TAKE TOO LONG TO ACHIEVE

The old argument put forward by many farmers that the cost impacts of establishing shelter and the impediment of investing in benefits that are only gained in the long-term may be misguided. Many farmers make medium-term investments in herd reproduction without question, and place long term value on this even though they won't see any return in milk value and income until 3 years past initial semen purchase.¹⁵

A snapshot of this investment can be seen when looking at the expected costs for female cows joined in, for example 2011.

- Purchase of semen (June 2011)
- Synchrony program for herd or maiden heifers and AI costs July (2011)
- Pregnancy testing November (2011)
- Live calf born May (2012) – rearing costs (milk or milk replacer, muesli, pellets, straw, horn removal, tagging, vaccinations and drenches etc.)
- Weaning, pasture grown and eaten, silage and or pellets over summer, crop and a summer drench for worms August (2012-May 2013)
- Joining program for these heifers (July 2013)
- Pregnancy test November (2013)
- Calving May (2014)

The same reference suggests that in relation to the reproductive investment above, the establishment of tree

plantations could be done at the same time as the farmer purchases semen for joining, and those trees planted in the same year within 2 years would be providing a beneficial impact on those same animals seeking some protection.

He contends further that he has planted over 20,000 trees on his farm in the last 20 years and strongly believes in the benefits trees have on a dairy farm and would do it all again for the benefit he has witnessed to his animals and the wildlife that has re-appeared in his area.

Innovations such as automated milking systems have the potential to free up labour for other enterprises such as farm forestry or for establishing biodiversity and/or shelter planting.

Other innovative approaches include vegetative strips to deal with nutrients, growing algae on ponds as a recyclable nutrient source, organic farming and biodynamic farming systems that import less nutrients, and agroforestry systems for multiple benefits as is practiced in New Zealand.



Source: SA Government (2012).

SOIL ACIDIFICATION

Soil acidification is a particular problem on soils having a low initial base status and where cropping and/or grazing with legumes is practised. Most pasture and crop species grow poorly on acid soil – some minerals are rendered unavailable (e.g. P or Mo) or too soluble, leading to Al or Mn toxicity or loss of N, Ca, Mg and K through leaching.

There is evidence that trees in pastures have prevented soil acidity increasing, possibly through their trapping of nitrate and by their substantial additions of Ca in leaf drip and litter return.

Many affected soils are duplex, with topsoil being acidic and clay subsoils alkaline, so that trees may bring this alkalinity to the surface.¹⁶

References suggest 70% or more of areas under cropping in the Corangamite and Glenelg-Hopkins regions are thought to be at moderate to high risk of acidification.¹⁷

Even well-buffered soils will eventually become acid under clover pasture, probably including the dairy soils in SW Victoria, and action may be needed in future to reduce the effect



Multiple layered windbreak utilising indigenous species.

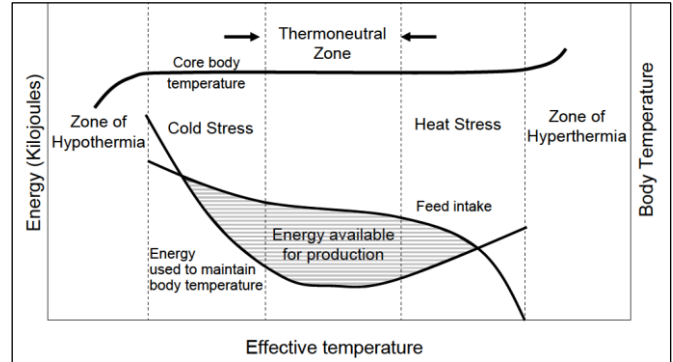
PRODUCTIVITY BENEFITS



General

Please note: the following research findings relate to specific sites and therefore cannot be expected across all farm sites with varied climate, topography and soil fertility zones. The findings relate to trials in a particular location at a particular time.

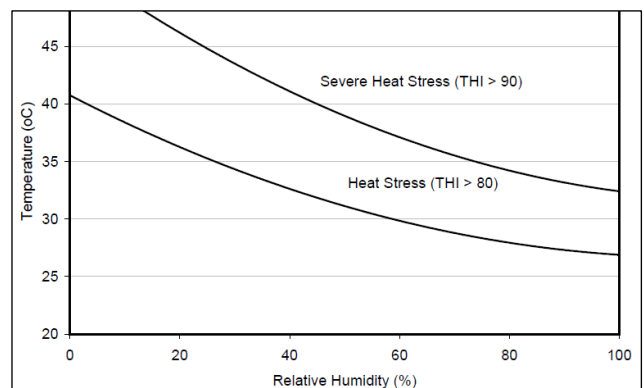
- Shelter reduces animal stress (heat/cold) and animal maintenance energy needs, providing more energy for production.¹⁸
- Increased shelter for stock, pasture and crops increasing productivity.¹⁹
- If 10% of the farm is dedicated to shelterbelts; the potential reductions in wind speed can amount to between 33-50%.²⁰
- Greater livestock gains result from increased pasture supply and reduced environmental stress; such gains have potential to offset the loss of land occupied by trees.²¹
- Moderation of spray-drift.
- Less reliance on introduced pollinators.
- Reduced pesticide usage via natural biological control.
- Increased land values and landscape amenity.
- Increased ecologically sustainable property values, legacy for future generations, and diversifying future family income.
- Effective shelter placement can be used to dry out laneways, provide fire-breaks, stabilise roadways, utilise less arable areas.



Thermal neutral zone – The effect of temperature on animal production. (Source: Ames 1980)

Livestock – Dairy

- Sheltered areas have up to 17% estimated increase in dairy milk production.²²
- On a 27 degree (Celsius) day, unsheltered cows have 26% less milk production than shaded stock.²³
- Milk yields are depressed by cold at a rate of up to 1.34kg per day (4% fat-corrected milk).²⁴
- Over (approx.40-60 years) the lifetime of fencing and shelterbelt; total dairy production will increase by 30% (20% improved pasture growth, 10% improved milk production), and \$150/ha of sheltered pasture.²⁵
- Heat stress can markedly reduce stock fertility, milk production and increase mortality of calves.²⁶
- The use of trees can reduce heat load (summer) in cows by 50%²⁷ and heat loss in winter, and is more cost-effective than using electricity-driven sprinklers and fans while absorbing carbon dioxide.



Heat stress in dairy cows²⁸ (normal body heat range 38.2-39° C). (Note: THI – Temperature humidity index)

- THI > 72 = dry matter intake decline, reproductive performance decline
- THI > 75 = significant decline dry matter intake
- THI > 78 = significant decline in milk yield

New Zealand studies on cow welfare and responses to cold include²⁹:

- Behavioural and physiological responses to cold conditions can lead to poorer welfare and productivity. Thinner cows are more susceptible.
- Physiological responses to cold include stress responses, mobilisation of fat reserves, altered body temperature rhythms, reduced immune function and increased skin thickness.
- Behavioural indications that cows are cold are more obvious and include seeking shelter, increased time standing (possibly with a lowered head), lower feed intake, lying with head or legs tucked against the body and shivering.

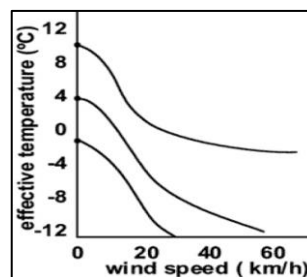
Livestock - Sheep

- Fewer stock losses specifically lambs and shorn sheep; shelter reduces livestock losses of new-born lambs with trials in SE Australia suggesting effective shelter reduces these losses by 50%.³⁰
- Sheltered sheep show a 31% increase in wool production and a 21% increase in live-weight (5 year trial).³¹
- In shorn sheep, shelter that reduces wind speed by 50% can reduce energy losses by 20%,³² increase live-weight by 30%.
- A 27% increase in survival of single lambs was observed in sheltered areas, but no advantage was evident to twins during periods of rain with temperatures < 5 degrees.³³
- Shelter is assumed to reduce lamb mortality by 5% per year and provide a 10% increase in pasture growth. DEPI research has also shown that sheep require 10% less pasture to maintain body heat in cold conditions. The combined effect of these benefits is expected to generate on average an extra \$0.93/DSE per year, which is equivalent to \$10,230.³⁴
- When comparing sheep in sheltered areas to those with no shelter there is a 50% reduction in lambing losses (average losses without shelter were 36% for twins and 16% for single births).³⁵
- Proactive management of improved and existing native pastures for increased land productivity has proved to be the difference between the top 20% of producers and the average.³⁶

Benefit	Belts 500 m apart	Belts 250 m apart
Wind speed reduction:	33%	50%
Improved plant growth:	+ 10%	+ 20%
resulting in extra production (gross margin \$ per ha)	+ \$16	+ \$32
Reduced maintenance energy requirement of stock: resulting in extra production (gross margin \$ per ha)	+ 10%	+ 17.5%
	+ \$16	+ \$28
Improved lamb survival (extra % units weaned):	+ 5%	+ 5%
resulting in extra production (gross margin \$ per ha)	+ \$3	+ \$3
Reduced losses of shorn sheep (ave. annual %): resulting in extra production (gross margin \$ per ha)	+ 0.5%	+ 0.5%
	+ \$1.50	+ \$1.50

Benefits from shelterbelts at maturity (Source: Bird 1996).

- Heat load reduction on ewes at joining and lambing results in lambs with faster growth rates and more wool during their first 16 months of life. Heat stress reduces wool growth by reducing feed intake.³⁷
- Cold stress reduces live-weight gain by 6kg in sheep and depresses wool growth by 25%, while heat stress reduces wool growth by reducing feed intake.³⁸
- Sheltered lambs exhibit a 50% reduction in losses (SW Victoria) and 28% increase in survival rates.³⁹
- Winter lamb mortality (birth to 48 hrs) reduced by 10% in sheltered areas.⁴⁰

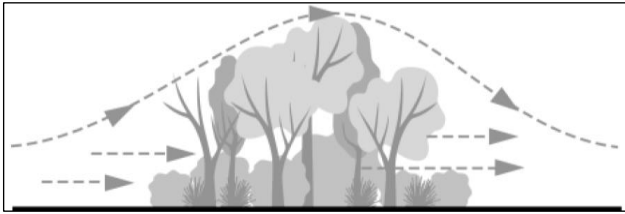


Impact of wind-chill and wetness on sheep⁴¹

- Sheltered off-shear wethers require only 1/3 the supplementary feed as unsheltered stock.⁴²
- Heat-load reduction on ewes at joining and lambing results in 10-16% more lambs present at marking.⁴³
- Cold stress reduces live-weight gain by 6kg in sheep.⁴⁴
- Heat stress is detrimental to ram fertility, ovulation rate and conception in ewes, and foetal development.⁴⁵
- The use of hedgerows using native shrubs/grasses is an emerging trend for specifically providing shelter in lambing paddocks⁴⁶

Location	Date	Loss	Windspeed (km/h)	Mean Temp. (C)	Rainfall (mm)
SW WA	Jan 82	100,000	7-11	16-24	100-250
SW Vic.	Dec. 82	50,000	32	10.8	21
SW Vic.	Mar. 83	100,000	32	16.0	42
SW Vic.	Dec. 87	50,000	20	10.2	48

Impact to off-shears sheep of climatic extremes (Source: Rowan Reid 2013).



Permeable shelterbelts planted with a variety of local native species provide habitat for native wildlife without creating turbulence.⁴⁷

Livestock - Cattle

- In cattle – efficiency of production (live-weight gain or milk output per unit of feed) is improved by shelter; shading and protection from high-humidity alleviates stress, and improves milk production and weight gain.⁴⁸
- Protected areas of farms have a 20% to 30% higher yield than unprotected areas, with annual benefits of \$38-\$66 per hectare.⁴⁹
- Cold stress reduces live-weight gain in cattle by 31% over several weeks.⁵⁰
- Heat stress reduces stock fertility, weight gain, and increased mortality of calves and sheep, and may cause abortion and under-sized calves.⁵¹
- Shorthorn cows show reductions in cud-chewing in unsheltered areas and increased rumination, reducing productivity.⁵²
- With regard riparian revegetation, yearling steers with access to fresh water gain 23% more weight gain than drinking dirty water.
- A recent modelling study estimated that milk production was reduced by even a short period of cold conditions (1-3% of days).
- Exposure of New Zealand dairy cows to a week of cold and wet conditions (mean 3.4°C, 3 mm of rain for 15 minutes/hour, wind 7.1 kmh) produced dramatic effects on the cows' physiology.⁵³

Effective Temperature (°C)	Extra Energy Required (%)	Extra Hay or Grain Required (kg/cow/day)	
		extra hay	extra grain ¹
-1	0%	0	0
-12	20%	1.6-1.8	0.9-1.0
-23	40%	3.2-3.6	1.8-2.3

Effective temperature and additional feed required to meet the cow's energy requirements⁵⁴

Case Study – Russell and Maxine Napper (Dairy Farmers – Gippsland, SE Victoria)



Multiple row windbreaks/shelterbelts (Source: Dairy Australia 2012).

The land around Sale has been kind to Russell Napper's family over the generations. However salt started to impact the farm in the early 1990's and as the water table rose to dangerously high levels and salt began to creep to the surface, he knew he had to act. They set about since 1991 to re-establish native vegetation on the farm and have seen the water-table dramatically fall and the quality of the landscape, pastures and the herd improve.

Russell and Maxine Napper say they have an obligation to leave the land in a better condition than they found it and suggest that trees make a better dairy farm by reducing salinity, keeping cows warmer (winter) and cooler (summer), encouraging pasture growth, and making it a better place to live and work, not to mention increasing the farm's value.

On the hottest days cows once crowded around the trough with the dominant cows gaining access while the heifers missed out. With trees and resulting shade the dominant cows may take all the shade but the heifers are able to access water.

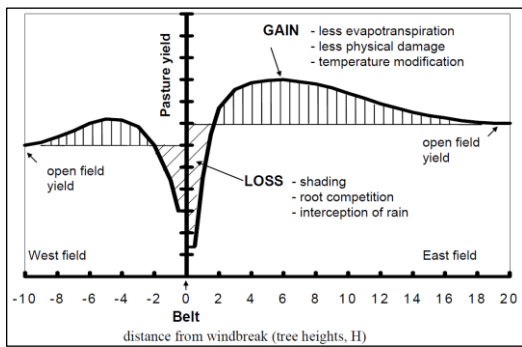
The Napper's believe trees are the single most important factor in maintaining a happy herd – on very hot or cold days the herd is clearly happier in paddocks with trees in them and better able to cope with extremes in temperature.

With extreme temperatures pastures thrive in the shelter afforded by planned tree plantings. They maintain that giving over land to trees has seen pasture and potential profitability grow significantly.

Since the start of the planting program there has been a three-fold increase in dry-matter consumed per hectare. Taking better care of the land has resulted in better milk production. 'We produce 1.5 million litres of milk off 60 hectares and 220 cows – as productive as anywhere'.⁵⁵

Pasture production

- Shelter improves plant growth and increased pasture and crop production, by reducing moisture loss from soils and transpiration in crops and pastures; shelter reduced the loss of water from soil in late spring by 10-12mm.⁵⁶
- On one farm protected areas had a 20% increase in average annual growth pasture growth.⁵⁷
- Plots sheltered by windbreaks had 18% more pasture.⁵⁸
- Sheltered pastures lose 12mm of water less than open pastures during the spring growing season.⁵⁹
- Major gains in decreased animal stress and greater pasture production in winter can support an extra 1-3 sheep/ha.⁶⁰
- Gross value of pasture output is at its highest level when the proportion of tree area on a farm is at 34%.⁶¹
- Shelter can increase agricultural production such as increased wool production, increased pasture growth (10-60%) therefore increase stocking rates.⁶²
- There is growing evidence that soils around trees contain elevated amounts of organic material and a higher nutrient status, thereby promoting pasture growth.⁶³



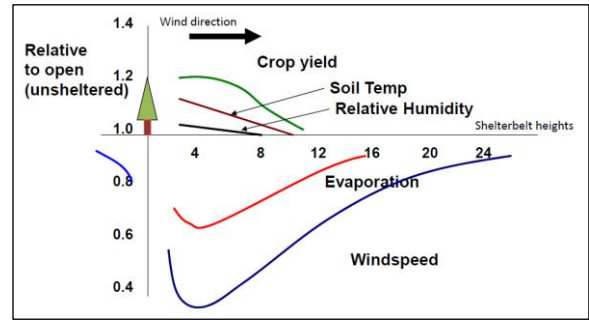
Shelter effects on plant growth and factors that influence losses in the competitive zone and gains in the shelter zone⁶⁴

- There is no major evidence to indicate a large effect of shelter on pasture growth. What evidence there is suggests a possible 10% increase in the sheltered zone, matched by an equivalent reduction in the competitive zone.
- The loss of production from the land taken up by the trees would possibly result in a net loss of overall production, in terms of pasture grown. However, this loss would also more than likely be more than offset by the modified microclimate and reduced stress to the stock, resulting in lower maintenance energy expenditure.⁶⁵

Cropping

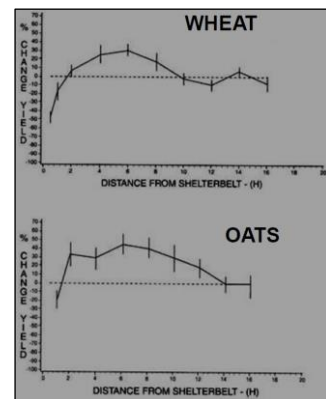


- Shelterbelts increase crop yields, even allowing for cropping land lost from paddock and near-shelter competition.⁶⁶
- Windbreaks increased crop yields by 25%. Although trees rob the crop for a distance equal to about twice their own height, they shelter a much larger area, extending downwind for at least 15 times their own height.⁶⁷
- Shelterbelts can potentially be effective for a distance 12-15 times the height of the tallest tree, with protection of some crops observed at up to 25 times the height.⁶⁸
- Increases in crop yields in Australian studies include: 22% for oats, 47% for wheat⁶⁹ in areas of above 600mm annual rainfall.
- Sand-blasting at seedling stage of cereal crops leads to reduced plant growth, due to moisture stress and physical damage.⁷⁰



The microclimate behind shelterbelts.⁷¹

- An increased net cereal yield of 15% per annum was attributed to shelterbelts;⁷² in Rutherglen, Victoria, an increase in wheat and crop yields in sheltered zones estimated between 22% and 47%.⁷³
- An increase in Lupin yield by 19-22% when the area of shelterbelt was included in the net yield/ha, and an increase of 27% on the Lupin crop area between the windbreaks.⁷⁴



Crop productivity and distance from shelterbelts.⁷⁵

Biosecurity benefits – all industries

- Increase in pest insect predators by increasing habitat.
- Decrease in chemical spray drift by reducing wind speeds.
- Providing a natural barrier to fungal spores carried by wind and in dust.
- Reducing soil particle movement by reducing wind speeds during cultivation, harvesting etc.
- Facilitate healthier stock/crops and greater resilience to pests and diseases.
- Restrict unwanted stock movements, prevent stray movement into and out of property.
- Disease control advantage (preventing nose-to-nose contact, which can spread diseases like *strangles* or *pestivirus*)(prevent access to waterways with *Johnnes*).
- Weed control advantage (trees and bushes can stop the spread of serrated tussock, thistles, cape daisy).
- Managerial advantages (in keeping various groups of animals separate and creating usable laneways for moving stock and vehicles)⁷⁶.

Landscape values

- Long-term development of 30% of total farm contributes to a more environmentally sustainable land use, reducing salinity and erosion, with the remaining land better managed and fertilised as productivity increases.
- Land protection benefits; control of groundwater recharge and salinity; deeply-rooted trees provide necessary recharge control.
- Shelterbelts reduce topsoil loss via reducing wind scour and rapid drying of soils; removal of clay and silt particles by wind contain much precious nutrients; reducing paddock wind speed by half, will reduce wind erosion to one-eighth (1/8).⁷⁷
- Shelterbelts placed above and as buffers along watercourses, reduce stream sedimentation and eutrophication, improve water quality, and reduce soil and nutrient run-off from paddocks. Interception of nutrients before entering water storages improves water quality for stock.
- Stabilise soil surface; reduce waterlogging, also useful in non-arable areas such as those impacted by gully erosion.
- 90% of sediments and nutrients can be prevented from entering waterways by maintaining riparian vegetation of 10m from the top of the bank. Shade trees along waterways decrease the amount of light, thereby reducing excessive weed growth and possible toxic algae.⁷⁸
- Improved landscape amenity and aesthetics. Potential fire protection; as localised wind speeds can be reduced.⁷⁹

Land values

- Farms with some shelterbelts and remnant vegetation increase capital value by 15%.⁸⁰
- *NSW Valuer General* valued the best vegetated farm at \$140ha more than the district average value; in more fertile areas there was a 35% premium over average values.⁸¹
- Add aesthetic value to the landscape by screening undesirable sights and increasing property value⁸²

Shelterbelts and fire protection

A shelterbelt can reduce wind speed which affects the rate of fire spread. Observations have shown the value trees have in protecting farms from fire which may seem counter-intuitive.

As opposed to a forest fire that generates intense heat and creates 'spotting' of fires, these conditions are rarely found on open farm land. On open land the passage of a fire front is largely dependent on wind speed and the amount of dry

grass on the ground, with a small increase in wind speed gives a much greater increase in fire speed.

Many referenced sources suggest the message is clear that the use of shelterbelts to reduce wind speed will enable the speed of the fire front to be reduced to the point where a brigade can contain the blaze. A good windbreak can reduce wind speed to 30% of that in the open and will decrease the fire speed to about 20% of that in the open.⁸³



Limitations of shelterbelts

- The need to understand the limitations of shelterbelts if designing for positive impacts.
- Cost of establishment, maintenance, land lost to production, and may harbour pest species.
- In low rainfall cropping situations competition from shelterbelts impact on soil moisture within areas proximal to the belt of vegetation⁸⁴
- Fire risks are an issue if incorrectly sited – some consideration should be given to the use of some exotic and deciduous species to reduce flammability and provide increased light in winter⁸⁵.
- Potential "rain shadow" effect in the lee of shelter belts.
- Increased competition to adjoining pastures in areas of low rainfall and soil fertility – this is reduced by using less competitive species.
- Reductions in growth and pasture quality during winter when shaded by east-west shelter belts.
- Reduced carbohydrate reserves in pastures from deep shading in winter.
- Impermeable barriers (such as rows of Cypress trees) can create turbulence on the windward and lee-side of the belt and may even serve to increase wind speed.⁸⁶
- Ecological considerations will raise costs and protection may be needed to meet these costs. Experience in Germany indicates that, without subsidies, and for an annual milk yield below 7000 kg/cow, sustainable farm management is not possible, except as a short-term transitional measure. Similar concerns were observed for other countries in the EU.⁸⁷

Gregory (1995) lists the disadvantages of shelterbelts as:⁸⁸

- loss of grazing area, reduced pasture growth near the belt
- costs of fencing and shelterbelt maintenance
- compaction/pugging near belts that are too dense and encourage cattle to congregate close by
- fertility transfer within the field where belts are too dense – resulting in an accumulation of nutrients in the stock camps close to the belt
- disruption of drains by tree roots
- stock poisoning – a potential problem with some species (e.g. cypress, pine, sugar gum)
- providing a harbour for pests and pathogens



Source: SA Government (2012).

BIODIVERSITY BENEFITS

The *CSIRO* names key ecosystem services provided by well-designed shelterbelts:⁸⁹ biological control, climate regulation, erosion control and sediment retention, soil formation, water regulation, nutrient cycling, pollination, raw materials, food production, catchment management and biodiversity conservation.

- Reduction of pesticide use; biological control of insect pests of pasture where a diverse array of trees and shrubs is maintained; biological control is performed by birds, parasitic wasps and other animals; flowering plants species such as Sweet Bursaria (*Bursaria spinosa*) and Silver Banksia (*Banksia marginata*) provide habitat for pasture-grub parasitising wasps (Scolid and Thynid).⁹⁰
- Mixed-species in older shelterbelts with fallen logs provide habitat for robberflies, lacewings, ladybirds, hoverflies, mantids and bee-flies which all parasitise pasture grubs and wingless grasshoppers.⁹¹
- Sugar gliders utilise Acacia gums (Black wattle – *A.mearnsii*) and Eucalypt sap in spring/summer, and feed on insects including moths and pasture scarabs, and consume up to 18,000 scarab beetles per hectare per season, and 3.25kg of insects per year.⁹²

- Honeyeaters generally inhabit the understory including shrubs amongst Eucalypts and are able to consume 24-36kg of insects per hectare per year.⁹³



Utilise wide and mixed species shelterbelts to increase biodiversity.
Source: Mallee Futures (2012).

- Birds and Bats are insectivorous and require mixed species plantings and the development of hollows; the diet of insectivorous bats such as the Southern Freetail Bat comprises 80% Rutherglen Bug.⁹⁴
- Insectivorous bats can consume up to half their body weight in a single night. In the northern plains their diet consists of mainly moths, beetles and bugs, with some species consuming spiders and mosquitoes.⁹⁵
- Magpies will consume up to 40 scarab larvae per bird per day.⁹⁶
- 100 *Straw-necked Ibis* consume up to 25,000 insects per day (locust & grasshoppers); natural insect control on an adjoining 100,000ha of crop land was worth an estimated \$675,000 per year (Barmah Forest area).⁹⁷
- Lizards (Skinks & Geckos) feed heavily on insects and also depend on ground rock, fallen timber, and dead trees for refuge.
- Provide potential wildlife corridors for animal and genetic transfer across the landscape.
- Tree and shrub species diversity reflects wildlife diversity; size of shelterbelts and remnants, proximity to water, proximity to corridor linkages, age structure of vegetation, diversity of flora and therefore fauna.⁹⁸
- Increased sediment filtration and therefore increases in water quality and aquatic life in local waterways.
- Lowering of water tables to reduce salt loads in local streams.
- Return of bird and other wildlife species.

SHELTERBELT DESIGN

The value of whole-farm planning

A well-considered whole-farm plan ensures objectives including landscape integrity, biodiversity, agriculture and forestry activities are provided for. Many cost-effective digital mapping (geographic information systems) programs can be downloaded from the internet and used with appropriate data to complete a farm map as the basis for development of a whole farm plan.

More information on *FarmPlan 21*, a whole farm mapping and planning course run for farmers, is available in Victoria here: <http://www.depi.vic.gov.au/agriculture-and-food/farm-management/farmplan-21>

Farm planning allows evaluation of the efficiency and impact of current land-use, and agricultural operations.



Whole-farm planning is critical to locating shelterbelts for multiple benefits.
Source: DEPI Victoria (2013).

The location of a shelterbelt is influenced by considering all site features such as: property infrastructure, prevailing and seasonally problem winds, soil types, problem areas of erosion and salinity, remnant vegetation, use of non-arable areas, and other on-site specific features. It is therefore important to specifically design the shelterbelt to suit the required purposes/benefits.

Please note that the following discussion is a general introduction to shelterbelt design information and is not exhaustive. The section 'Useful Resources and Links' at the end of this document provide plenty of information on shelterbelt design.

Design general information

- Plant shelterbelts and windbreaks perpendicular to the direction wind protection is required; these are not always the prevailing winds.
- Cornered and right-angled windbreaks provide protection from a range of wind directions.
- Site shelterbelts and windbreaks where there is maximum benefit to stock, crops, pasture and wildlife.
- Assess the site prior as part of planning to understand site limitations (topography, drainage, erosion, shallow soil) and useful native plant associations to use.
- Investigate what other benefits can be gained by linking remnants, protecting riparian zones, preventing salinity.
- Crops are most affected by hot-drying winds from the north.
- Livestock are at risk from cold winds and rain from the south-south west, and summer heat and wind from the north.

- During summer, shelterbelts protect crops and pasture from severe evapotranspiration and wind and soil erosion; such situations benefit from a grid of shelterbelts using north-south and east-west orientations.⁹⁹
- This configuration provides shade for stock at different times of day and protection from winds from all directions and prevents permanent shading of pasture and crops as they receive sun at different times of the day.
- Generally speaking the extent of protected area equals the length of the belt x height of shelterbelt x 10, while the minimum length should be 10 times the height (tallest layer); therefore if 25m height, the shelterbelt should be 250m long. Networks of belts or finishing belts in low areas is preferred as with having shelterbelts wrap-around at the ends¹⁰⁰
- Effective locations are high in the landscape (ridge-line) produces the greatest area of protection.¹⁰¹
- Planting on contour lines should be avoided as localised frosts can result.¹⁰²

How wide?

- Shelterbelts incorporating trees and shrubs in 3-6 rows (12-24m wide) are effective for most situations.
- Wider and strategically-placed shelterbelts promote increased biodiversity habitat and reduced 'edge-effects, increasing the 'core' area, and reducing species predation.¹⁰³
- Many references suggest shelterbelts of 2-4 rows (or direct seed equivalent) with 2m between the outer rows and fence.
- Single-row belts should only be used on land of highest value, and where space is limiting, and must include species with uniform 'ground-to-top' foliage cover.
- 1-2 row shelterbelts are cost-effective options but require a uniform and high survival rate.
- Smaller trees and shrubs are placed on the outside of central tall trees to prevent shading out.
- An average shelterbelt (3 rows/12m wide) can promote 12 species of woodland bird; if widened to 25m (7 rows) the number rises to 17.¹⁰⁴
- If shelterbelts are wide enough they can incorporate limited stock grazing and provide protection in severe weather situations.
- To minimise cost, utilise existing fence-lines for shelterbelt establishment.

Spacing and Density

- Density of shelterbelt depends on purpose; if providing additional habitat for native fauna use multiple rows including dense shrubs, which also reduces wind funnelling under the shelterbelt.
- A denser windbreak offers higher protection over short distances, while a less-dense windbreak provides less protection but over a greater distance.¹⁰⁵
- As density is reduced, turbulence is also reduced and downwind protection increases; a medium density of 40-60% is recommended.¹⁰⁶
- Density is modified by the structure of the shelterbelt and influenced by: height, density, number of rows, width, species used, foliage texture, spacing, length and continuity of shelterbelt.
- To reduce the potential of wind-tunnelling under Eucalypt canopies, multiple rows should be used and the role of non-local species and exotic species could be considered.



Allocasuarina are useful species to provide porosity, trap weed seed, and filter spray-drift.
Source: Reafforestation.com.au (2012).

Row design

- Row-planting provides easier access for maintenance but not necessarily most effective shelterbelt.
- Close-plantings produce a faster result, utilising the fastest growing, local-provenance species in the centre row.
- Using local fast-growing trees as the central species supports slower growing species.¹⁰⁷
- For row-plantings in general, larger trees are planted 3-4m apart, with larger shrubs 2.5-4m apart; lower shrubs are placed 1.5-2.5m apart.
- The number of plants to use per hectare varies by site and localised climatic and soil variables, with a guide as 1000 plants/ha (1km long x 10m wide @ 3m plant spacing).

Direct seeding options

- Direct seeding utilises locally-collected seed of suitable tree, shrub, grass, and ground cover species in various proportions (to mimic mixed native vegetation).
- If established within and prior to average and above average rainfall, direct seeding produces a more diverse, 'natural' and self-maintaining shelterbelt over time.
- Initial weed and pest animal control is critical in the first 2-5 years for successful establishment.
- Seed requirements for direct seeding based on 0.5kg / ha.
- Seed ratios should be based on 1/3 trees and 2/3 shrubs.
- DPI and local consultants can provide detailed information on direct seeding projects and species suitable.

Species selection

- Provenance - source seed for planting and direct seeding if possible from the closest remnants (within 20km) of the same soil type, and drainage position in the landscape (species most adapted to site climatic and physical characteristics).
- Local provenance species have a higher establishment and survival rate as reported in numerous studies.¹⁰⁸
- Species selection is based on the objectives of the shelterbelt and influenced by height, growth rate, and density characteristics.
- Fodder, honey and timber species can be incorporated to provide periodic or long-term resources.

Establishment and Maintenance



Establishment of seedling or direct-seeded shelterbelts is detailed in many other accessible references on the internet but include: weed control (6-12 months prior to planting), fencing, deep-ripping and planting/direct-seeding; steps that should be well planned prior to commencement. The quality of site preparation directly relates to shelterbelt

success and therefore the potential biodiversity and productivity benefits.

Management after planting includes: control of browsing animals (rabbits, hares, wallabies, kangaroos, livestock, snails), and grass and broad-leaved weeds. Selective sprays used in late spring after planting may continue for the first 5 years of establishment. Gaps from death of plants must be replenished with replacement seedlings.



Source: DPI VIC (2009)

CONCLUSION

Well-designed, established and maintained shelterbelts, support ecologically sustainable agriculture, which benefit from increased productivity, sustainability, biodiversity, and property and landscape values.

Sustainable whole-farm planning incorporating shelterbelts and biodiversity values can also potentially increase the 'environmental credentials' of a farm, supporting best-practice and increased market share.

Shelterbelts are not a short term panacea but a mid to long-term proposition that requires a flexible approach and site-specific solutions. More than this they contribute to equity for future generations, position farmers for a 'low-carbon' future, and adaptation to a changing climate.



Source: Eucalyuca Native Services, SA (2010)

USEFUL RESOURCES, LINKS



Source: SA Government (2010)

See DEPI (Victoria) Landcare Notes:

<http://www.depi.vic.gov.au/environment-and-wildlife/community-programs/landcare/victorian-landcare-gateway>

LC0137: Shelterbelts for Livestock Protection
LC0138: Shelterbelt Management
LC0139: Shelterbelts and Wildlife
LC0104: Tree planting and aftercare
LC0133: The benefits of using indigenous plants

Cost/benefit calculation

<http://www.evergraze.com.au/library-content/shelter-investment-tool/http://www.evergraze.com.au/>
<http://www.environment.gov.au/node/35739>
<http://www.teara.govt.nz/en/shelter-on-farms/page-5>
<http://www.cleanenergyregulator.gov.au/About-us/Governance-accountability-and-reporting/annual-report/Pages/3-12-national-carbon-accounting-toolbox.aspx>
<http://www.csiro.au/Outcomes/Climate/NCASpartnership.aspx>

Government incentives for shelterbelts

<http://www.daff.gov.au/climatechange/cfi>
<http://www.climatechange.gov.au/reducing-carbon/carbon-farming-initiative/activities-eligible-and-excluded>
<http://www.carbonconscious.com.au/what-we-do/faqs/>
<http://www.abc.net.au/radionational/programs/backgroundbriefing/features/the-carbon-conundrum/4532742>
<http://theconversation.com/revegetation-helps-fix-the-climate-but-australia-would-rather-clear-land-16164>
<http://www.depi.vic.gov.au/agriculture-and-food/food-and-fibre-industries/food-and-fibre-marketing-cooperatives-grants>
<http://www.regional.org.au/au/roc/1991/roc1991131.htm>
<http://www.csiro.au/Organisation-Structure/Flagships/Sustainable-Agriculture-Flagship/Carbon-Land-use-Theme.aspx>

Carbon farming

<http://www.daff.gov.au/climatechange/cfi>
<http://www.climatechange.gov.au/reducing-carbon/carbon-farming-initiative/reforestation-tools>
<http://www.climatechange.gov.au/reducing-carbon/carbon-farming-initiative/activities-eligible-and-excluded>
<http://www.dairyingfortomorrow.com/index.php?id=47>
<http://www.greenhouse.unimelb.edu.au/Tools.htm>
<http://www.depi.vic.gov.au/agriculture-and-food/farm-management/weather-and-climate/understanding-carbon-and-emissions/carbon-and-emissions-frequently-asked-questions/on-farm-greenhouse-gas-accounting-tools>
<http://www.carbonconscious.com.au/what-we-do/faqs/>
<http://www.abc.net.au/radionational/programs/backgroundbriefing/features/the-carbon-conundrum/4532742>

Livestock – Dairy

<http://www.thedairysite.com/articles/837/cold-stress-in-cows>
<http://www.dairyingfortomorrow.com/index.php?id=96>
<http://www.dairyingfortomorrow.com/uploads/documents/file/Case%20studies/trees%20benefit%20sale%20dairy%20farm.pdf>
<http://www.dairyingfortomorrow.com/index.php?id=52>
<http://www.nzffa.org.nz/farm-forestry-model/resource-centre/tree-grower-articles/tree-grower-november-2008/natives-and-those-problematical-pivots/>
<http://www.coolcows.com.au/Infrastructure/Paddocks%20and%20laneways/trees-for-shade.htm>
<http://milkmaidmarian.com/2011/12/28/our-green-investment-already-begins-to-grow/>
<http://bioprotection.org.nz/news/story/shelterbelt-research-gets-funding-dairynz>

Shelterbelt design

http://www.gwlap.org.au/docs/Windbreaks&Shelterbelts_single%20page%20style.pdf
<http://www.southernwoods.co.nz/documents/info2-DairyFarmPlanting2.pdf>
http://www.farmforestline.com.au/pages/2.2.1_shade.html
http://live.greeningaustralia.org.au/nativevegetation/pages/pdf/Authors%20C/9_Cleugh.pdf
http://www.nzif.org/free_issues/NZIF27_2_1982/DOB5A0A6-04FE-448D-9A86-D6DE1F802941.pdf
<http://www.dairysa.com.au/LinkClick.aspx?fileticket=ZoHXJi8RA24%3D&tabid=76&mid=421>
http://www.heytesburylandcare.org.au/attachments/DAPFS5_Shelterbelts.pdf
<http://www.depi.vic.gov.au/forestry/innovation-research/technical-reports/private-forestry-research-database>

http://www.strathewenlandcare.org.au/page/landholder_grants_and_projects.html#Shelterbelts
http://www.landcares.org.au/wp-content/uploads/2012/09/NSW_PWS_Factsheet7NativeShelterbelts.pdf
http://www.palservices.com.au/pages/belts_shelterbelts.html
http://www.tagsforpots.com.au/index_files/Revegetation%20Planner%20guide.pdf
http://www.nativegrasses.com.au/field_days/Rowan_Reid.pdf
<http://www.teara.govt.nz/en/diagram/15600/shelter-belts-effect-on-wind>
<http://www.dpi.vic.gov.au/agriculture/farming-management/business-management/property-management-systems/core-components-for-farm-planning-services>
http://live.greeningaustralia.org.au/nativevegetation/pages/pdf/Authors%20B/8b_Bird_SWVT.pdf

Livestock - Sheep

EverGraze Phone Seminar – Turning reproductive performance into reality.
 EverGraze Exchange – Improving the survival of lambs
 EverGraze Action – Perennial grass hedges for lamb survival
 EverGraze Case Study – Currie’s: Sheltering their lamb income
 EverGraze Supporting Site – Curries, Casterton
 Broster JC, Rathbone DP, Robertson SM, King BJ, Friend MA (2012a) Ewe movement and ewe-lamb contact levels in shelter are greater at higher stocking rates. *Animal Production Science* 52, 502-506.
 Broster JC, Robertson SM, Dehaan RL, King BJ, Friend MA (2012b) Evaluating seasonal risk and the potential for windspeed reductions to reduce chill index at six locations using GrassGro. *Animal Production Science* 52, 921-928.
 Robertson S, King BJ, Broster JC, Friend MA (2011) Survival of twin lambs is increased with shrub belts. *Animal Production Science* 51, 925-938.
 Robertson SM, King BJ, Broster JC, Friend MA (2012) The survival of lambs in shelter declines at high stocking intensities. *Animal Production Science* 52, 497-501.
 Broster JC, Dehaan RL, Swain DL, Friend MA (2010). Ewe and lamb contact at lambing is influenced by both shelter type and birth number. *Animal*, 4(5), 796-803
<http://www.evergraze.com.au/library-content/hamilton-key-message-shelter-improves-lamb-survival/>
<http://www.abc.net.au/site-archive/rural/content/2010/s2965219.htm>

Shelterbelt benefits - general

<http://www.environment.nsw.gov.au/resources/vegetation/nvinfoSheet1.pdf>
<http://ianluntresearch.wordpress.com/2012/11/21/can-livestock-grazing-benefit-biodiversity/>
http://live.greeningaustralia.org.au/nativevegetation/pages/pdf/Authors%20Y/2_Yunua_a_et_al.pdf
[http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdxc2073](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdxc2073)
<http://www.westvicdairy.com.au/Portals/0/content/publications/industry-reports/natural-resource-management/Chapter5-Shelter&Productivity.pdf>
<http://ageconsearch.umn.edu/bitstream/12505/1/53030185.pdf>
<http://www.landcare.org.nz/files/file/746/Biodiversity%20for%20Farmers.pdf>
<http://www.bom.gov.au/climate/current/special-statements.shtml>
<http://www.farmbiosecurity.com.au/farmer-vet-wins-biosecurity-award/>
http://www.daff.gov.au/_data/assets/pdf_file/0007/721285/csiro-bom-report-future-droughts.pdf
<http://www.dpi.vic.gov.au/agriculture/farming-management/soil-water/erosion>
<http://www.teara.govt.nz/en/shelter-on-farms/page-1>
<http://www.livestocklibrary.com.au/handle/1234/22004>
<http://www.dpi.vic.gov.au/agriculture/beef-and-sheep/beef/handling-and-management/cattle-shelter-guidelines>
http://www.clw.csiro.au/publications/farming_ahead/2000/Helen%20Cleugh_Nov2000.pdf
<http://www.urbanwateralliance.org.au/publications/UWSRA-tr16.pdf>
http://www.landcareonline.com.au/?page_id=6048
<http://www.abc.net.au/radionational/programs/backgroundbriefing/features/the-carbon-conundrum/4532742>
<http://www.crcforestry.com.au/publications/downloads/Carbon-short-report-final-for-online.pdf>
<http://www.carbonconscious.com.au/what-we-do/faqs/>

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We are an incorporated, not for profit Landcare Network based in South West Victoria, Australia. Our Network region covers the Local Government areas of Moyne and Warrnambool City (approx. 4% of the land area of Victoria). For more details of our work go to www.basalttobay.org.au

<http://youtu.be/orRJ6MyC-xg> - Direct seeding opposite the Warrnambool Cheese and Butter Factory, Allansford.

<http://vimeo.com/87375963> Lisette talking about farm shelter belts as part of the film making for “Rediscovering Country” <http://vimeo.com/99883046>

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Australian Government
 Department of Agriculture



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What does no shelter and shelter look like?



No shelter – they huddle in the warmest spot and stand not eating.



Even a single row of trees can prove much welcomed shade in the heat of summer.



Good native shade and shelter on King Island -famous for strong, grass fed beef.



A mixed agro- forestry shelter belt – income/shelter/shade/biodiversity, Stewart Property Deans Marsh.