Livestock shelter from trees – a review

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Abstract
New Zealand is a windy country with extremes of temperate climate. Cold southerly and warm sub-tropical winds ensure a varied existence for farmed livestock. There are good examples of livestock shelter throughout the country, yet few farmers actively manage their animal enterprises to include shelter. Research results indicate there are production responses in milk production, liveweight gain and lamb survival to the provision of shelter. However, welfare and animal stress benefits have been difficult to substantiate. Caring for livestock should be the top priority, with an added bonus of satisfying marketing requirements. Strategically planted shelter will enhance our countryside, our image and our economy.

Keywords: animal welfare, livestock, shelterbelts, trees

Introduction

Animals must maintain body temperature within a comfort range otherwise they expend energy to keep warm or cool. For mature ruminants, the comfort range is large (Palmer *et al.* 2003) and varies according to species, breed, nutrition, stage of pregnancy and lactation, as well as other factors. Mature sheep and beef cattle can withstand harsh weather with little or no impact on productivity (Gregory 1995). However, it is a very different situation for lambs, calves and newly shorn ewes (Holmes & Sykes 1984). Dairy cows tend to be the most vulnerable of grazing ruminants to cold, wet conditions because of their shorter coat length and the high physiological demands placed on them (Palmer *et al.* 2003). Such conditions are particularly likely to occur in the southern regions of the country (e.g. Southland) where winter conditions are variable and subject to sudden change.

The provision of some level of shelter, particularly against wind, is known to alleviate many of the adverse effects of inclement winter conditions on livestock (Flanagan 1995). There is a lack of knowledge of early and sensitive indicators of impending cold stress, as the animal typically maintains its body temperature until heat loss suddenly reaches unsustainable levels. At the other end of the spectrum is the provision of shade to reduce the effects of heat and sun on animals, such as the potential incidence of cows suffering from sunburn and skin cancer. The relative importance of shade versus shelter has not been determined in New Zealand. Shade is assumed to be more important in northern areas and shelter more important in southern and higher altitude locations, but this may not be true for all situations.

The New Zealand dairy industry is expanding into areas with harsher winter climates (e.g. Central Plateau, Southland and Canterbury) and established shelter has sometimes been removed to create more productive units. This removal of shelter and shade is now a major concern.

Farmer attitudes to shelter have generally been positive. Morey (1988) found in a survey of 2109 farmers on their attitude to farm forestry, that 57% of respondents had established shelterbelts and the most important reason for planting trees was for stock shelter. In a recent study in Australia, Nelson *et al.* (2003) concluded that establishing shelterbelts was widely supported amongst farmers because there was minimal conflict with their existing farming. This survey of 65 dairy farmers in South West Victoria found that practices that were beneficial to them, such as shelterbelts for protecting dairy cattle from rain and wind and mature trees for shade in summer, were widely supported.

This paper summarises the principles of shelter design, discusses some research results and the environmental benefits of providing shelter to livestock.

Principles, design and management of shelter

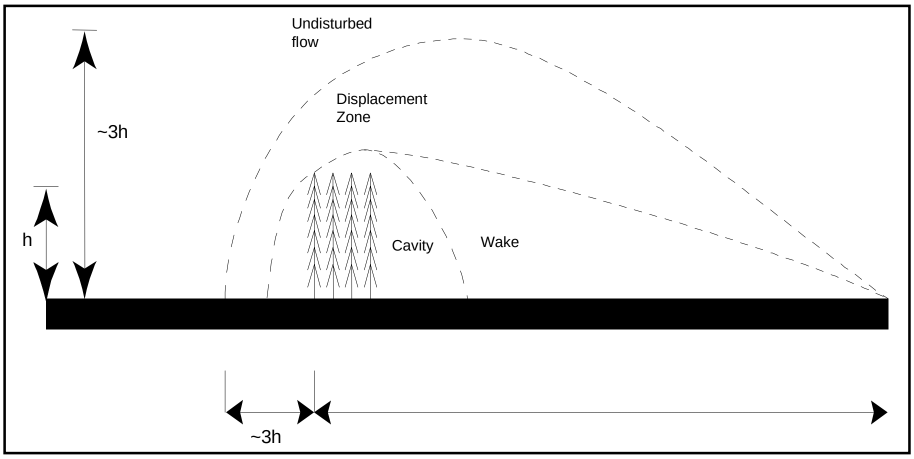
Modifying the flow of air (wind) is the principal way in which shelterbelts are used to alter microclimatic conditions. Modifying the airflow not only affects the wind speed but also the turbulence, intensity, temperature and humidity of the local microclimate (Table 1).

Table 1. Changes in microclimatic conditions in different zones of a shelterbelt, adapted from Palmer *et al.* (2003).

Zone	Increased	Reduced
Displacement	Windspeed above shelterbelt Air turbulence	Windspeed at ground level Sunlight close to shelterbelt
Inside Shelterbelt	Windspeed (only for very open shelter belts) Night-time temperatures	Windspeed Daytime temperatures Sunlight
Cavity	Air turbulence Daytime Temperatures Air humidity Lodging/abrasion of pasture Waterlogging on wet soils	Wind speed Night-time Temperatures Sunlight close to shelterbelt
Wake	Daytime Temperatures Air humidity Carbon dioxide	Windspeed Air turbulence Wind erosion Water Loss (evapotranspiration)

The wake zone is the region in which the fast moving air displaced above the shelterbelt (displacement zone) begins to mix with the slower moving air that has filtered through the trees (cavity zone) – Figure 1. The wake zone is the area with the main potential microclimatic benefits.

Figure 1. Wind flow zones created by the flow of wind over a shelterbelt and their scale in relation to the height (h) of the shelterbelt, adapted from Palmer *et al*. (2003)



Different shelterbelt designs create slightly different effects on wind flow. Dense multi-row belts force the air hitting the trees up and over by the pressure ahead of the shelterbelt. The wind descends and returns quickly to its original speed at ground level, and turbulence may occur quite close to the trees in the cavity zone (Gregory 1995). Dense shelterbelts (low porosity) are ideal for young livestock because they are more-or-less impermeable and they block the wind, but do not encourage animals to move out into grazing areas (Palmer *et al.* 2003). Semi-permeable belts allow air to filter through, reducing the cavity zone. There is less turbulence and an increased area of shelter that encourages more extensive and even grazing patterns (Palmer *et al*. 2003).

In designing a shelterbelt, the main function is to give protection to stock against cold winds and to provide shade. The three most important features that control the amount of protection provided by a shelterbelt are its siting, tree height, and porosity. The shelter zone is generally considered to be about 14 times the height (h) of the trees, 3 h of which is on the windward side (Gregory 1995). Porosity is a measure of how open a shelterbelt is, and how easily the air can flow through it. A medium porosity belt (40–60%) provides the greatest leeward area of protection whereas a dense belt (20% porosity) deflects the wind creating turbulence and reducing the protection downwind (Palmer *et al.* 2003). Porosity can be modified during the life of a shelterbelt to suit site objectives and in this way livestock shelter can be improved. Dense shelter is good for young or vulnerable livestock for short periods in cold, wet, and windy weather. However, there is a build up of fertility patches close to the shelter as a result of dung and urine from sheltering stock (Hawke *et al.* 1999). A medium porosity belt (semi-permeable) gives less intense changes in the microclimate and is best suited for sheltering extensive grazing areas. Porosity can be estimated visually, or can be measured accurately using digital images (Horvath *et al.* 1997). Horvath's study at Forest Research proposed the development of interactive models to describe shelterbelt tree growth and responses of livestock to shelter. Unfortunately, these models were not completed.

Multi-row belts have generally been dense, perhaps because they have not been managed for their timber, whereas two row belts may consist of different tree species, one providing low shelter and the other pruned to allow air flow and for timber production.

Shelterbelt designs are generally for specific purposes – dense shelter for maximum protection, porous belts for more even protection over a wider area and timber production. However, there may be a case for variable permeability to combine these specific situations within a shelterbelt on a farm.

Shelterbelts are usually designed to be at right angles to the prevailing wind and are more effective on flat land than ridge tops. On rolling contour, shelterbelts should run up and down a slope to drain off cold air and avoid winter frost pockets. However, orientation to the sun should also be considered. Shelterbelts planted in an east/west direction have definite shady and sunny aspects whereas those planted in a north/south direction allow sun on both sides of the belt at some stage during the day.

Livestock shelter can also be in the form of individual trees randomly spaced within a paddock. Stock congregate in the shade of these trees, often causing soil erosion, pathogen build-up and weed infestations (M.F. Hawke, unpubl. data). To ameliorate these effects, individual trees should be opened up as much as possible by pruning lower branches and reducing crown width. Hedgerows, riparian plantings, agroforestry blocks (wide spaced trees planted into pasture for timber production) and shelter paddocks are all variations of shelter in common usage on New Zealand farms.

In designing shelter for livestock, local knowledge of seasonal wind patterns is most important, as is knowledge of suitable tree species that grow well in the district. A range of tree species are suitable for shelterbelts, but they must be fenced to prevent stock access. Some tree species such as *Cupressus macrocarpa* and *Pinus radiata* have caused abortion in cattle where pruned branches have been grazed (Knowles & Dewes 1980).

A farm shelter plan is recommended so that any local council restrictions, topography and landscape effects are considered. While shelter for livestock may be the main consideration, visual impact can benefit farm values and visitor impressions.

Research results

The role of shelterbelts in protecting livestock has been well documented by Gregory (1995). Under cold conditions shelter can improve growth rate and ovulation rate in cattle and sheep, wool growth rate in sheep (Doney *et al.* 1973; Lynch & Donelly 1980) and reduce lamb mortality and abortions that are induced by hypothermia (Alexander *et al.* 1980). Providing shade during hot conditions can improve milk yield, freedom from mastitis, and conception rates in dairy cows and growth rate in fattening cattle (Roman-Ponce *et al.* 1977; Stott & Williams 1962; Alexander 1967).

Considerable livestock shelter research has been conducted overseas (Gregory, 1995), but in New Zealand there have only been limited studies. Holmes *et al.* (1978) found that dairy heifers grew faster than control twins when they were provided with shelter and Holmes & Sykes (1984) concluded that in general, shelter produced more benefits for sheep than cattle and that shelter reduced lamb deaths in the 48 hours after birth. Pollard (1997) noted no productive gains from providing shelter at lambing time in Southland but anecdotal evidence from a postal survey indicated a reduced loss of lambs. There are several anecdotal reports on the value of shelter to livestock in New Zealand. For example, in severe snowstorms, beef cows with access to shelter and adequate feed had better chances of surviving than those without shelter (Gregory 1995). The provision of shade shelter reduced stress on deer (de Klein *et al.* 2003). A recent study (Roberts, unpublished) indicated that cows started to use shade when the ambient temperature reached 25°C and shade use lowered body temperature, but did not affect overall time spent grazing. Research in Queensland (Davison *et al.* 1988) showed cows with access to shade had lower body temperatures, lower somatic cell counts and increased daily milk yields. Flanagan (1995) concluded in an experiment near Canberra that shelter reduced stress levels in sheep and cattle. In the USA, Schultz (1984) reported that cows provided with shade often drink less and spend less time loafing at the water trough.

In the 1990s, the emphasis on shelterbelt research was to measure the shelter effects on adjacent pasture production, soil nutrients and soil moisture (Hawke & Tombleson 1993; Hawke & Gillingham 1996; Hawke *et al.* 1999). The general conclusion from these studies was that there was no increase in pasture production due to shelter. In fact, there were slight decreases in pasture production close to shelterbelts due to competition for soil moisture and nutrient transfer. However, a previous study in Canterbury (Radcliffe 1985) showed a positive pasture response to shelter. No beneficial changes in pasture species composition have been measured as a result of shelter (Hawke & Tombleson 1993; Radcliffe 1985). Pasture quality has not been assessed, but the higher soil and herbage nutrient levels close to belts, particularly potassium, suggest that livestock prefer to avoid this nutrient rich pasture.

Shelterbelt research petered out in the late 1990's due to changes in funding priorities but there is now a resurgence of interest, particularly in the animal welfare sector.

Complementary and environmental effects

Shelter can achieve multiple goals for both the landowner and the environment. Shelter trees can be a haven for birds, give shelter for homes and buildings (e.g. stock yards), be aesthetically pleasing, and increase the tree species in an area. Shelter can also screen noise and reduce odours associated with livestock operations. However, it can also harbour insect pests, bird populations, vermin and pathogens, encourage undesirable weeds, and give unnecessary shading. Dense shelterbelts provide nesting sites for birds that damage crops e.g. starlings and sparrows and den sites for possums (Porter *et al.* 1994). The use of native plants, particularly those naturally occurring in the locality, help to preserve the local character and provide forage for bees.

Forest Research conducted a comprehensive shelterbelt (called "Timberbelts") research programme in the 1990s, primarily to investigate timber production and properties. Timberbelts were measured throughout the country and trials established on species selection, spacing and silviculture. Unfortunately, this programme was terminated before results were complete.

Animal welfare

Shelter has been recognised as being important in New Zealand, primarily in the colder climates of the South Island. Because the benefits are not always easy to define and shelterbelt management requires some added skills, farmers have often not considered their many attributes. The world market for New Zealand produce is becoming more discerning and environmentally aware and demands traceability so that animal welfare requirements are met. A Code of Recommendations (MAF 1996) and minimum standards for the welfare of sheep include sections on shade and shelter. For this reason alone, farmers have to be more familiar with welfare considerations and act in a responsiby. Meat company programmes include in their manuals, statements about the need for shade and shelter to eliminate animal stress and protect themselves from the extremes of weather (B. Binnie, pers. comm.), but these statements are very non-specific.

Animal welfare has always been an important issue for the livestock farmer and it will increasingly become part of the New Zealand marketing ploy. Farmer attitudes to shelter for livestock are generally positive.

Conclusions

The provision of shelter for livestock is much more than purely an economic decision. The scattering of research results in New Zealand indicates that animal production is improved with good shelter. The word 'welfare' means satisfactory health and contentment. With humans, this may be relatively easy to measure, yet it is not universally achieved. With animals, it is in the eyes of the beholder, or more correctly the consumer, so despite everything that farmers may do, it is the market place that will determine ultimate success. Good shelter should be carefully planned. The guidelines for doing this are well established. There are numerous examples of poor shelter throughout the countryside and these are costly and often inconvenient to rectify. The push for biodiversity, indigenous flora and environmental outcomes will no doubt encourage more natural shelter to our landscape.

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