



Department of Agriculture

# Farmnote



## Using windbreaks to reduce evaporation from farm dams

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Evaporation is generally regarded as the most significant contributor to water loss from farm dams in south-west Western Australia. Typical annual evaporative losses range from 1 m in the south-west of the wheatbelt to more than 2.5 m in the north-east. Considering typical farm dams are only 3-4 m deep, it is clear that any savings gained from reducing evaporation can significantly improve their efficiency. This is particularly important during prolonged drought or low rainfall.

Recent research has shown that using windbreaks to slow the wind over the water surface of dams can reduce evaporation by 20 to 30 per cent.

### How windbreaks work

Windbreaks have been used for many decades as shelters that can alter the downwind micro-climate.

This occurs primarily because they reduce the wind speed and turbulence of the airflow for some distance downwind of the shelter itself. The extent depends on the nature of the windbreak (e.g. artificial barrier or tree shelter belt), its density, height, and orientation to the wind.

The height of a windbreak determines the length of the sheltered area downwind. The length of this sheltered or *quiet zone* is between five and ten times the windbreak height. Further downwind, beyond the quiet zone, the airflow gradually recovers to its upwind velocity in the more turbulent *wake zone* (see Figure 1).

The density or *porosity* of a windbreak determines its effectiveness in reducing wind speed and turbulence. Generally shelters are considered more efficient if they are moderately porous. Very solid windbreaks are

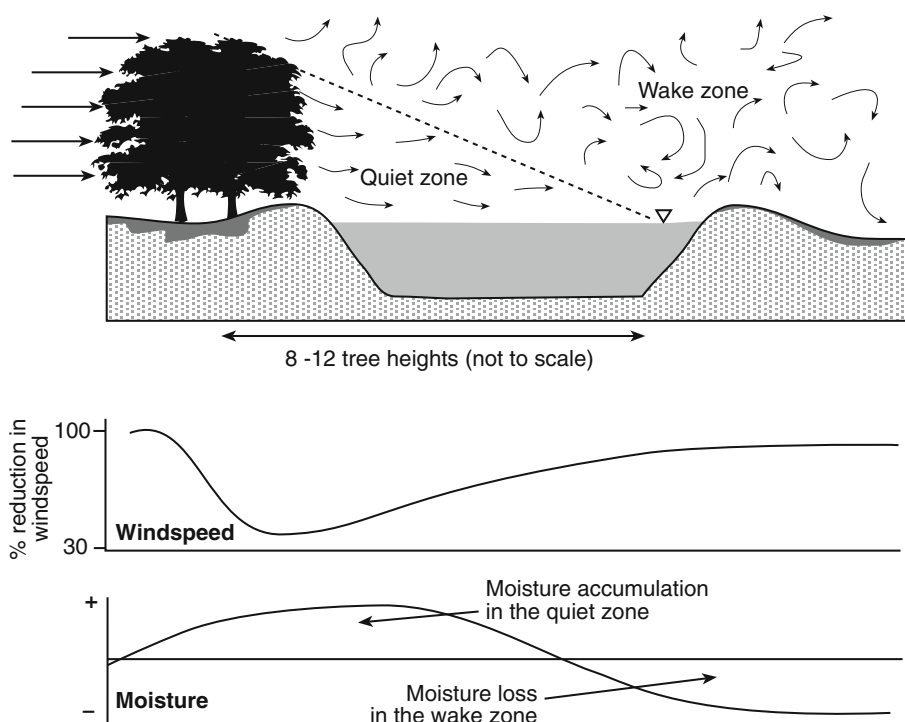


Figure 1: a) Dam windbreak system showing the quiet and wake zones created downwind; b) wind speed reduction downwind compared with upwind; c) relative moisture levels downwind of the windbreak showing an increase in the quiet zone and decrease further downwind.

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better at reducing wind speed, but this comes at the cost of inducing more turbulence - the very process that is responsible for removing moisture from the water surface and lifting it into the atmosphere. Moderately dense shelters (50 to 70 per cent optical porosity) do not reduce wind speed so much, but do not generate excessive turbulence and are therefore more efficient, particularly for medium to large dams.

## How windbreaks reduce evaporation

Evaporation is the process of releasing water from a surface into the atmosphere. This is increased by turbulent eddies of wind. The amount of evaporation depends on:

- the wind speed (i.e. how fast water can be moved away from the surface); and
- humidity difference between the air and water, termed the humidity gradient. Dryness of the air and temperature determine the *humidity gradient*.

The high evaporation losses experienced from farm dams across south-west WA in the summer result from two main factors:

- hot, dry easterly and northerly winds that originate from the deserts of inland Australia; and
- high surface water temperatures due to the small and turbid (i.e. muddy and opaque) nature of farm dams.

Windbreaks reduce evaporation by limiting the amount of hot air that passes over the warm water surface. Tall windbreaks may also shade the water during the morning or afternoon, thereby helping to decrease temperature.

Windbreaks result in the development of a *moisture blanket* by reducing the rate at which moisture is removed from the water surface. The development of this moist layer then acts to further reduce evaporation by limiting the humidity gradient between the water surface and the overlying air (see Figure 1c). When designing or placing a windbreak, it is important not to have the dam in the turbulent wake zone, as turbulence will prevent the *accumulation of moisture above or near the surface*

*of the dam* even if the average wind speed is reduced compared to its upwind value.

Tree windbreaks may also contribute to reduced evaporation loss by 'humidifying' the air through transpiration, before it passes over the water surface. This will enhance the moisture blanket over the dam and further decrease the humidity gradient.

By decreasing the effective wind speed, the size and number of waves generated on the surface are reduced and therefore the area in contact with the atmosphere is minimised, restricting the evaporation potential.

## Other benefits of windbreaks

In the past, windbreaks have been promoted as mechanisms to assist agricultural productivity by:

- preventing soil erosion;
- improving crop growth;
- protecting crops and pasture from wind damage;
- providing shade and shelter for livestock;
- reducing groundwater recharge;
- increasing biodiversity.

## Windbreak design

The modifications that windbreaks make to airflow and micro-climate can be complicated by the generation of turbulence. Therefore it is important to plan and design them carefully to ensure efficiency. The following design guidelines are recommended when planning a new windbreak, or if a new dam is to be situated downwind of an existing windbreak or remnant vegetation.

### Windbreak types

Both artificial barriers and tree shelterbelts can be effective in reducing evaporation. Artificial barriers have the advantage of working immediately and there is no complication with tree roots competing for the water supply and impacting on the dam's integrity. However, artificial barriers are generally not as robust over the long-term, and can become expensive if they are to withstand strong winds. The main benefit of trees is that

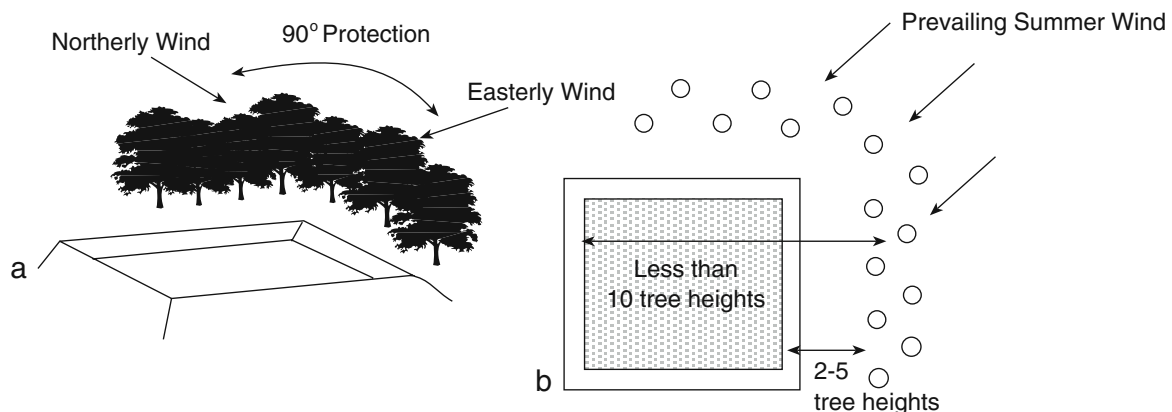


Figure 2 : a) Dam protected from summer easterlies and northerlies by windbreak on two sides; b) plan view of a dam-windbreak system showing spacing of trees for a two-row windbreak (not to scale).

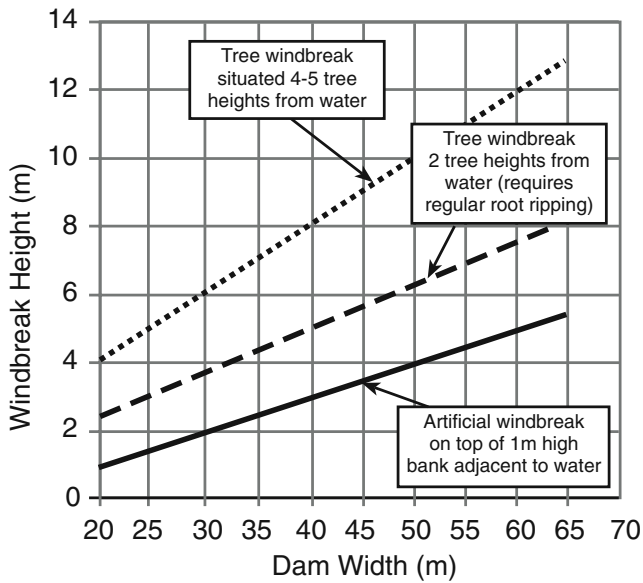


Figure 3: Minimum windbreak height required as a function of dam width (assumes a square dam) for three different scenarios.

they are cheap and provide more shelter for livestock. The longer establishment time is a disadvantage.

### Orientation

When planning a windbreak, it is important that it reduces the impact of the prevailing hot, dry winds generated during summer - typically northerlies and easterlies. Although strong winds blow from the south and west

throughout the year, they are generally humid and cool and responsible for limited evaporation losses.

Wind speed and direction data can be obtained for most locations from the Department of Agriculture website: <http://www.agric.wa.gov.au/climate/clig/Climinfo/AWSSITE.htm>. Normally, a tree windbreak is planted along two sides of the dam (see Figure 2) to provide the best protection during summer.

### Windbreak height

The length of the sheltered zone that develops downwind is directly proportional to windbreak height, therefore the minimum height will depend on the size of the dam (see Figure 3). As a general rule, the length of the quiet zone is around eight times windbreak height. Trees should be placed two to five windbreak heights from the water body.

### Distance from water

Artificial windbreaks should be constructed as close to the water as possible, i.e. on the bank of the dam. Here, the bank itself will provide protection from wind and improve overall results.

Tree windbreaks must be planted some distance away to prevent their roots penetrating the base of the dam and removing water. Depending on the species, lateral root growth is considered to be around two to five times the height of the tree. If the trees are planted closer to the water, regular ripping of the roots is recommended.



## Considerations for tree windbreaks

### *Choice of species*

A wide range of species is available for windbreaks. Consider amount of water use, lateral root growth, foliage density and growth rate. A combination of species is also recommended to maximise foliage uniformity and biodiversity.

### *Tree spacing*

To prevent zones or spaces through which wind can be channelled, it is important to minimise gaps in the foliage. Windbreaks should consist of several rows of trees where the trunks of one row are aligned with gaps in adjacent rows (see Figure 2b). The exact spacing will depend on species. Shrubs can also be used to reduce the gaps.

## *Protection from stock*

During establishment of a windbreak it is desirable to exclude stock so that the trees can reach their maximum height rapidly. When the windbreak is mature, stock can create a bare zone near the ground that can cause wind to funnel near the surface. However, allowing stock access to the shade offered by a windbreak will decrease the amount of water they drink. Therefore it is recommended that stock only be allowed access if the understorey is well developed.

## **Acknowledgments**

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