RESEARCH

HOW MUCH WATER DO TREES USE?

by Stuart Crombie

A major aim in forestry is to be able to predict tree water use over a wide range of conditions. By knowing how trees respond to drying soils, hot dry atmospheres, salinity and other factors we will also be able to predict which trees will do best in particular locations.

While each species has it's own way of reacting to different environments, some general rules have been worked out by studying trees in natural woodlands and plantations.

These studies have shown that there is no magical tree which is completely drought tolerant. In the long-term tree water use cannot exceed long-term water inputs (i.e, rainfall) without the tree suffering severe drought. Assemblages of trees and understorey species in native stands have developed links ("feedback loops") between water availability and water use to keep total water use in balance with long-term water inputs. Dryland agroforestry seeks to recreate some of these balances between water use and rainfall to achieve long-term survival and water use targets.

Total leaf area is the main determinant of water use of both single trees and whole stands. The drop in leaf area from the karri forest, through the jarrah forest and wandoo woodlands to the mallees and scattered trees in deserts is an expression of this balance between water inputs from rainfall and loss from leaves. The bigger trees (which have more leaves) along water courses compared to hillsides and the stunted trees on shallow soils over rock reflect smaller scale differences in water availablity.

Growth rates are also very tightly linked to leaf area because it is the leaves that capture light and use it to make sugars that eventually end up as wood. In a low rainfall environment, having fewer leaves is one of the simplest ways for a tree to reduce water use and avoid drought. However, because the low leaf areas reduce growth rates, a low leaf-area tree avoids drought stress at the risk of being out-competed by faster growing neighbours. Fast growing trees with large leaf areas and high rates of water use dominate in moist environments such as the karri forest where access to light, not water, is the key to competitive success.

Trees have evolved many strategies to limit water loss in low rainfall environments. While all trees can close the pores (stomates) in their leaves to reduce water loss, some leakage still occurs. Some species avoid this by simply dropping their leaves in the dry season while others hold their leaves but have to tolerate increasing drought stress during summer.

Mallees often have shiny leaves hung vertically in self-shading bunches to reflect a lot of the midday heat that drives transpiration. The arrangement of the multiple trunks and branches of mallees in spreading "V" shapes form a collection system directing water to the base of the tree and away from the roots of competitors. Mallees sometimes have built-in "flow restrictors" between their roots and leaves so that even when soils are moist the leaves are semi-drought stressed and limit water loss to conserve soil water for use later in summer.

Watertables are difficult for trees to use as roots seldom function efficiently when submerged in water. Groundwater is particularly difficult for roots to grow in as watertables are frequently low in oxygen, may contain toxic acids or ions and are often saline. Trees growing over watertables are often not drawing their water from the watertable itself but from the thin layer of moist soil immediately above it. Unfortunately, capillary rise of water into this zone is slow and trees dependent on it seldom transpire at high rates. Typical maximum rates of withdrawal from watertables (or the capillary zone above it) are equivalent to the input of 1-2 mm of rainfall per day.

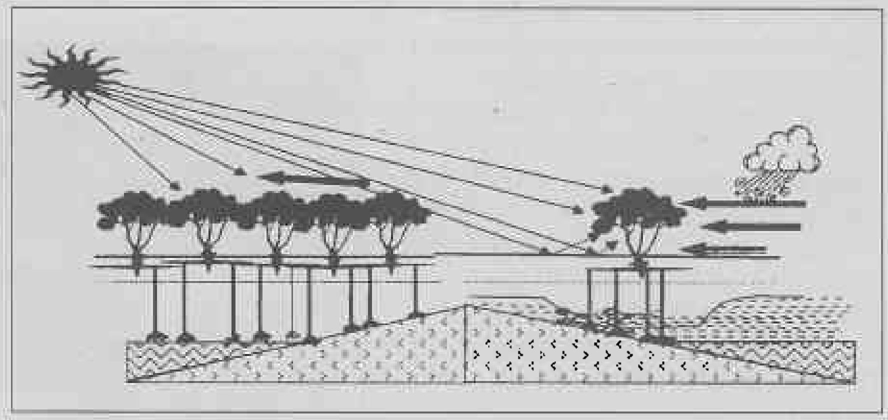

Figure 1. Trees growing in isolation in paddocks are in a more drying environment, with a greater part of the canopy exposed to heat from the sun or ground, and to greater wind movement than are trees in woodlands where they tend to shelter each other. Although paddock trees have less competition for soil water from neighbours, they are also at greater risk of rising watertables which may lead to root loss through immersion or salinity.

continued on page 12

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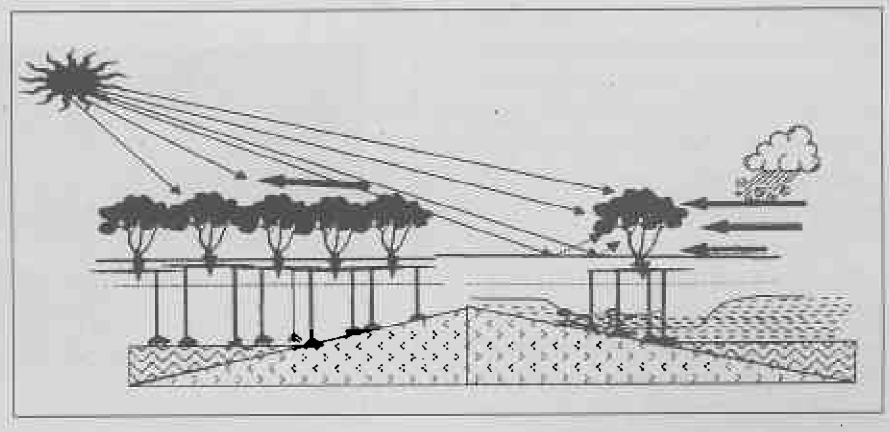

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continued on page 12

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continued from page 11

However a tree able to use groundwater, may gain enough advantage over competitors by surviving or growing during dry periods, to dominate the site.

Some actual figures

Under ideal conditions trees can use water at rates very close to that at which water evaporates from a lake or dam. In the agricultural regions of South-West WA this varies from the equivalent of 1-2 mm of rainfall equivalent per day in winter to 4-6 mm per day in early summer. Trees restrict water use as soils dry out during summer so that late summer water use may be 1 mm per day or less. Overall, tree water use cannot be more than rainfall in the long term without the tree drying out soils and causing their own local drought.

This means that the "average" vigorous tree growing in a plantation stocked at 1000 stems per hectare could use from 10 to 60 litres per day (i.e. 1-6 mm x 10,000 $m^2 ha^{-1}$/ 1,000 trees ha^{-1}) depending on water availability and the time of year. In another stand with fewer but larger trees, water use by the stand may not change much but the total water use will be spread between the smaller number of larger trees so that each tree uses more water. In comparison, on a sunny day in spring when soils are moist a wheat crop might use around 4 litres per square metre of crop (or the equivalent of 4 mm per day of rain). The annual crop would of course not use any water when the plants are absent during summer.

A tree growing on its own in an open paddock will typically use more water than the same sized tree in a large plantation or woodland. This is because the plantation tree is partly sheltered from winds and shaded by it's neighbours.

These differences partly explain why shade trees left when paddocks are cleared are often so stressed; they have the relatively small root systems of a forest tree suddenly having to provide the greater water requirements of a paddock tree. Young trees are usually more able to adjust than older trees.

Summary

We can measure how much water single trees, tree belts or large plantations use. From this we can work out if tree water use is in balance with rainfall or is causing drying of soils. While the former is ideal for wood growth in plantations, the latter is good for controlling watertables and salinity. Alternatively, we can calculate how much water is flowing across landscapes to roots of single trees or trees in belts or determine if water is "leaking" below crop and tree roots to add to rising watertables.

The emerging picture is that trees in WA's agricultural and pastoral zones often have the capacity to use more water than is available, especially in summer. This extra water use capacity is going to be very useful in developing sustainable agricultural systems in which soil water balances are similar to those under the native woodlands (i.e. there is no buildup of watertables). However, skilled placement of the appropriate trees is anticipated to result in development of viable farming systems where only part of the land area is covered by trees and the rest of the landscape is used for annual cropping.

A major focus of current research is to match tree species with site conditions and water use to obtain the best possible long term yields from the trees and the crops they protect from salinity.

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BUSH DETECTIVE

Chris and Joan Moffet of "Bellaranga", Morawa, suggested this puzzle: -

Who made this heap, and why?

This pile of sticks is at the edge of a saline drainage area, part of the Yarra Yarra Lake system. The samphire flat flooded after the big rains the last two summers. Who made the heap, and why? Photo: F. Falconer

Ans: It's a swan's nest! They successfully reared young.