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Plants as pumps

By E. A. N. Greenwood, CSIRO

Native species vary greatly in their ability to pump ground water. CSIRO studies are measuring water use by different plants to plan revegetation strategies.

It is generally held that the primary cause of saline seepages on farms is the clearing of the native vegetation. This view rests on the assumption that pastures evaporate less water over a year than native vegetation. The resultant change in the water balance of the soil brings rising water tables to the surface.

Three compelling arguments support the evaporation hypothesis. First, native vegetation transpires over the whole year, as against six months for crops and pastures. Second, these extra six months are those of the highest evaporative demand. Third, it is argued that the original vegetation, because of its deep root system has access to a much larger supply of water from which to pump.

Plants differ in their ability to pump (transpire) water. When there is no shortage of soil water, the plant with the greatest total area of leaves (evaporating surface) and the greatest number of transpiring pores (stomata) is likely to pump the most water in a day. When the supply of water in the soil is low, the plant with the deepest root system may well be the best pump.

Although it is convenient to consider plants as pumps, vegetation has other powerful ways of influencing the water balance. All vegetation intercepts rainfall, which is eventually evaporated and trees are generally better at doing this than ground cover such as pasture. So a fourth argument for greater water use by the original vegetation may be added. That is, it allows less of the rainfall to drain to the water table. It would be more useful if we talked of plants as "evaporators" rather than as "pumps".

In southwestern Australia, summer and winter extremes of season have their effects on the evaporating power of plants. Evaporation from vegetation has two peaks during the year—one in winter arising from wet leaves and the other in summer arising from transpiration.

In winter, the low radiation from the sun (the driving force) is compensated for by low resistance to evaporation due to the frequent wetting of leaves.

In summer, particularly if the soil is dry, the effect of high radiation may be limited to some extent by very high resistance to evaporation due to the closure of stomata. That is, the leaves tend to be water tight.

In reclamation of salt-affected land it must be decided what type of vegetation, and how much of it, to plant. Types of vegetation could be salt-tolerant ground cover established on the scald, plantations of trees surrounding the scald, regeneration of the original vegetation on selected parts of the catchment, or pine plantations dispersed in some way more generally over the catchment. To make the best hydrological choice, the evaporation rate from each type of vegetation together with the flow rate of the aquifer or seepage area must be known.

Direct methods of measuring evaporation

There are several methods for measuring evaporation from plants and each has its place. The two methods most used in the salinity work are known as the humidity chamber and the ventilated chamber techniques.

With the humidity chamber method (Fig. 1) a freshly cut twig is suspended in a turbulated transparent box, and the rate of increase in the humidity is measured with a lithium chloride cell. This provides the transpiration rate of the twig. If the leaf area of the twig and the whole tree is known then the pumping rate of the whole tree can be calculated. This method is useful for trees of all sizes providing a representative sample of the twigs can be taken.

The most convenient large-scale method is the ventilation technique (Figs. 2 and 3) in which a transparent plastic capsule, open at the top, is placed over the tree. Air is blown through at a known rate and the increase in humidity of the air after it has passed over the foliage is determined with an infra-red gas analyser. This is the better method but it is much more elaborate and costly.

Pumping rates

The CSIRO has made some measurements of pumping rates and more measurements are planned. However, the information obtained is limited by instruments and staff. Measurements so far indicate a wide range of pumping rates between species and between regions of different average annual rainfall.
Fig. 2.—A small ventilated chamber

Fig. 3.—A larger ventilated chamber