# Salt of THE Earth

By John Williams

> Planting trees to manipulate water and salt levels in the Australian landscape is far from a simple exercise yet the results can be dramatic <



> Forests and woodlands with a great diversity of trees, woody shrubs and perennial grasses dominate Australia's native vegetation, which works to keep the balance between salt and water movements in the landscape. This perennial vegetation, with its relatively deep root systems, uses most available water, thereby minimising recharge (the amount of water that leaks past the root zone to groundwater). Native plants can manage both low rainfall and large salt stores in subsoils, regolith (mantle rock) and groundwater. Under native vegetation, the rate of leakage past the plant roots into the landscape's internal drainage systems was about equal to the drainage or discharge rates of water from the landscape into streams, wetlands and swamps. Healthy native ecosystems of forests and woodlands within catchments were in hydraulic and salt balance. The salt that was discharged slowly from the catchment balanced the input of salt from the atmosphere and geological weathering.

## SINCE SETTLEMENT

About 50 million hectares of forest and woodland vegetation have been cleared from the Australian continent since the arrival of Europeans in the late 1700s. This large-scale clearing, coupled with the introduction of annual crops and pastures, substantially increased the amount of water leaking beneath the root zone and entering the internal drainage and groundwater systems. Changes in native vegetation changed movements in water and salt, beginning the salinisation process. This land clearing has contributed to land and stream salinisation problems and, particularly in higher rainfall regions, caused large increases in run-off from former forests and woodlands into streams, rivers and wetlands.

In forests, trees have a key role in determining how much water flows beneath the root zone as drainage to groundwater and how much water flows over the surface and in shallow pathways within the soil to the stream (see diagram below right). It is how forests partition these flows that determines the impact of forest management on the catchments and rivers in the Australian landscape. Clearing of forests and woodlands increased the water available in many of our rivers. However, these additional water flows have since been allocated uses and thus problems with water availability arise due to increased consumption by irrigated agriculture, urban water use and the expectation of secure river-flow regimes that can support healthy rivers.

*Biography*

*Dr John Williams is a member of the Wentworth Group of Concerned Scientists. He was the chief of CSIRO Land and Water from 2001-2004.*

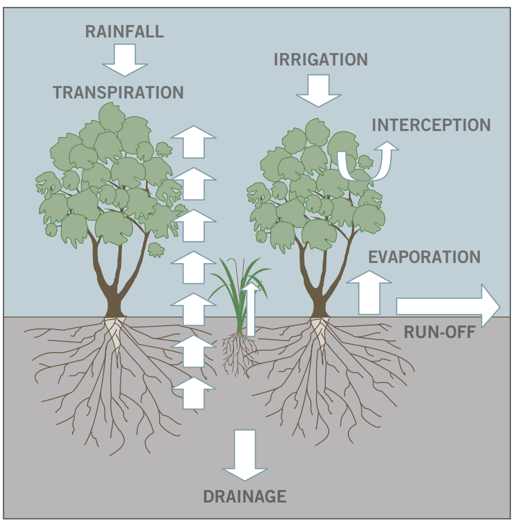
## FORESTRY'S RESURGENCE

There has been a surge of investment and activity in plantations, farm forestry and general revegetation in Australia. The essential design criterion of sustainable farming is to ensure that present-day flows of water, nutrient, carbon and energy match the magnitude of the flows that evolved to suit the way our landscape functions. This will require radical change to land use, incorporating both commercial tree production and revegetation with tree-dominant native vegetation.

Plantation and farm forestry, agroforestry, new agricultural production systems and restoring native vegetation present opportunities to create a landscape with a mosaic of vegetation that has a similar water-use pattern to the original native vegetation. This future landscape has the potential to both treat the cause of land and water degradation problems and to generate wealth sufficient to sustain viable rural communities. These landscape mosaics, in which forestry and agroforestry are integrated with new forms and patterns of agriculture, would yield products including fruits, nuts, oils, pharmaceuticals and bush foods, as well as a range of timbers, charcoal and biomass for energy generation. Most importantly, this tree-based mosaic has the potential to maintain and enhance biodiversity and delivers a suite of ecosystem services, including carbon sequestration, habitat diversity, salinity control and clean water.

## SALINITY CONTROL

In a report to forestry and agroforestry R&D corporations, hydrologist Emmett O'Loughlin and scientist Sadanandan Nambiar point out that, despite emerging opportunities for a resurgence in forestry plantations, farm forestry and agroforestry, they all face the challenges of achieving economic and ecological balance on a farm scale, catchment scale and regional scale. They identified that one major challenge is the management of interactions between tree plantations and the movement of water and salt in the landscape.



A recent CSIRO paper noted that when pastures or crops are replaced with tree plantations or tree-dominant native vegetation, there are two important changes that will determine the level of salinity in creeks and rivers that drain the catchments. The first is the reduction in the run-off and thus the flow of water in the stream (also known as the water yield). This occurs relatively quickly and is at its maximum when the canopy of the plantation or revegetation is closed. The reduction in flow is significant and increases in high rainfall zones (above 700 mm a year). In low to medium rainfall zones (400-700 mm a year), the reduction is often small and difficult to predict.

The second change is the amount of water that drains past the bottom of the root zone. Less drainage normally results in the lowering of local groundwater levels, though there are often time lags of months or years. As groundwater movement is the major mechanism by which salt is transported to the stream, a reduction in recharge also will reduce the rate at which salt is mobilised. Groundwater flow systems have relatively long lag times associated with the slow movement of water through the aquifers (10 years to hundreds of years), so the effect of reducing salt mobilisation on salt loads in streams will be delayed by a significant period. In most low to medium rainfall areas, reducing salt mobilisation produces a greater effect than reducing stream flow, and stream salinity is reduced. In other areas, this is not the case and stream salinity increases. The outcome for stream salinity may vary greatly over time as a result of differing time lags in the surface flow and groundwater flow.

The CSIRO's Commercial Environmental Forestry project (see opposite page) in Victorian catchments provides analysis that shows targeted planting to maximise stream salinity benefits can substantially improve efficiency without any marked impact on water yield loss or forestry production. This result highlights the importance of selectively targeting those areas where salinity benefits are greatest to optimise the effectiveness of new forestry or farm forestry plantations. This and other work by Forests NSW and CSIRO indicate that well-planned and strategically located reforestation and revegetation can address the hydrological imbalance that causes dryland salinity on farms and in streams, wetlands and rivers.

### REDUCING STREAM FLOW

O'Loughlin and Nambiar acknowledge that concerns have arisen that, in some situations, expansion of forestry on a large scale could diminish hydrogeological flows and threaten water availability or water quality. It is a long-established conclusion that forests use more water per unit area than grazing or cropping. In 2003, O'Loughlin and Nambiar summarised many of the issues concerning plantations and water balances. They noted that 'studies done so far have not discriminated between different types of forest cover or the changing dynamics of forest canopies where plantations are progressively thinned and harvested'.
In recognising that land use changes include the establishment of new plantations that reduce stream flow, the Wentworth Group of Concerned Scientists said that 'comprehensive water accounts must accurately reflect the impacts of such changes on water availability, including different combinations of grazing, cropping, forestry enterprises and other forms of revegetation, which reduces the volume of water reaching rivers and recharging groundwater systems'.



### DENMARK RIVER'S FRESH FUTURE

***One of Western Australia's rivers may be winning the salinity fight. Farmers and government authorities have been working since 1978 to reduce high salt levels in the Denmark River, which flows through WA's south coast region. More than 40 per cent of the upper catchment was cleared by the 1970s. Intermittently since the mid 1970s, water in the Denmark has been too saline for public supply. Without intervention, the average annual salinity could have peaked at 1,400mg of salt per litre at the Kompup gauging station and 700mg/L at the Mount Lindesay station.***

***Governments initiated measures such as reforestation and land acquisition in the late 1970s, to achieve a target of 'fresh' river water (500mg/L of salt) at the Mount Lindesay gauging station by 2020. These steps, together with actions to establish forestry plantations and perennial pastures, fence off vulnerable areas, revegetate stream lines, build drainage and manage surface water have resulted in a marked drop in stream salinity – a rarity in a major river system. This is the first major catchment in WA where there is a downward trend in salinity as a result of direct intervention through on-ground works – primarily revegetation and commercial forestry since 1988. If the trend continues, the Denmark River could potentially be a major water source for the Denmark-Albany region.***

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In some areas, industries and towns that depend on limited resources of fresh water have limits placed on their water use. Competition for water resources between forestry, revegetation with tree-dominant native vegetation and other uses can lead to disruption of industries and resource development, as well as community conflict. We are confronted by the often neglected fact that we may have more water in our streams and groundwater because of extensive land clearing. Communities have allocated this additional water without recognising why it is there.

Balanced land and water use policies, effective discussion and communication between stakeholders and land management agencies, and good quality biophysical data and predictions are necessary for attracting investment in a range of industries, including commercial forestry and revegetation programs, that are essential to combating land and water degradation. Debates on forestry and water often become adversarial, as though there is a simple solution to these complex issues. However, interactions between forests, catchments and rivers are diverse, and usually climate-, ecosystem- and hydrogeologically-specific.

## FUTURE LANDSCAPES

The future mosaic of vegetation in the Australian landscape needs to include an increasing proportion of forestry, farm forestry, agroforestry and native vegetation dominated by trees. These elements have the potential to both treat the cause of land and water degradation problems and to generate wealth to support rural communities. This vision for the future involves extensive land use change where new agricultural production systems, agroforestry, biodiversity plantings and commercial forestry will combine in new mosaics to yield both new forestry and agricultural products in company with a suite of environmental services. Forestry will play a key role in all of this.

In low to medium rainfall zones, and in salinised landscapes overlying responsive groundwater systems, the objectives for this land use change will be to reduce drainage to groundwater while minimising any reduction in water yield and thus stream flow. Well-targeted planting of forests and tree-dominated native vegetation in areas where the major salt stores are mobilised will ensure the best possible reduction of salt entering rivers with the least reduction in water yield. In some catchments, land use change that decreases water yield can also cause a long-term increase in river salinity. Thus, it is important to have appropriate tools that predict the effects of proposed land use changes and locations on water yield and salt flow to rivers. The impact of new plantations in reducing stream flows is greatest in high rainfall zones above 700 mm a year. If future plantations are established in low to medium rainfall zones, then this effect will be reduced. Research tools exist or are being developed to predict the impact of change in land use on the suite of environmental values. These tools can be used as a basis to help design landscapes.

It may be possible to substantially reduce plantation impact on water yield through careful on-farm planning, location of plantations, and management through silviculture such as thinning. However, these manipulations also need to be considered in light of potential impacts on productivity and economic return. In a CSIRO paper, scientists Phil Polglase and Peter Hairsine predicted that 'the establishment of new tree plantations in agricultural landscapes will have a range of environmental outcomes. Using the right scientific and planning tools, combined with alignment with regional community objectives, forestry aims to play an important role in realising net environmental benefits, with the added advantage of providing an economic return that will help pay for the scale of revegetation needed to address some of Australia's environmental problems'.

### VICTORIAN INITIATIVE

*The Commercial Environmental Forestry project, a collaboration between the Department of Agriculture, Fisheries and Forestry, CSIRO and Victoria's Department of Primary Industries, is an initiative to encourage carefully targeted revegetation of private land in low to medium rainfall areas. It is specifically studying the impact of different types of woody plantings such as commercial tree crops and conservation plantings, with the aim of providing environmental benefits as well as a greater variety of income opportunities for landholders.*

### FOREST TRIALS IN NSW

*Forests NSW has set up 47 demonstration trials in salinity-prone catchments across the Murray-Darling Basin in the 600-700 mm a year rainfall zone in NSW. The trials are on two-hectare sites with varying soils and rainfall. Some 400 hectares of plantations have also been set up on the Liverpool Plains. Ranging in size from 10 to 60 hectares, these plantations will answer questions on planting density and configuration, species mix, effects on salinity and site preparation. The Macquarie River trial has two 50-hectare plantations in salinity-prone sub-catchments of the Upper Macquarie. Scientists are gathering data on tree survival, growth and water use, as well as groundwater changes and establishment and management costs. NSW Forests is using a Liverpool Plains site to study changes in soil moisture, salinity and the watertable after trees are planted.*