Guest editorial

The response of Australian forests to a drying climate: a case study of the jarrah forest

There are many comments in national and state media on the apocalyptic effects that climate change will have on Australian forests and their biodiversity. These comments, based on reports produced by the World Wide Fund for Nature, the Bureau of Meteorology, CSIRO and the Geography Department, University of Western Australia, have forecast widespread flooding and loss of mangroves; increased cyclonic activity leading to damage to forests, woodlands and plantations; frequent 'megafires' which will incinerate the forests of the south-east and south-west; a rise in temperature of 4°C in the south-west leading to a loss of 3000 species, and decreasing rainfall that will render catchments near useless.

To my knowledge, these various claims have not been seriously challenged, or where they have, the responses have not been widely reported. The claims are repeated so often that they are now close to becoming accepted truth. A major concern is that possible practical solutions that can be implemented locally are not being offered. To many 'experts' the only 'solution' is rapid, massive, world-wide intervention, and even then this may not be seen to be enough. The experts also fail to recognise that current policies may well be adding to the problem.

Let me explain, citing an example from the northern jarrah forest of Western Australia (WA).

Long-term records of inflow into metropolitan surface water supply dams in WA show a marked downward trend. During the period 1911–1975, simulated inflows averaged 350 GL y^{-1}; this reduced to 175 GL y^{-1} from 1976 to 2000, thence to an average of 80 GL y^{-1} from 2001 to 2006 (a GL (gigalitre) is one million kilolitres). The year 2006 was one of the driest on record with a total inflow of only 40 GL. Water-tables in forested water-supply catchments have also fallen in recent decades (by 5–9 m) and the soil profiles are drier. Streams that had long been considered to be perennial ceased to flow in 2006, one for over three months. Consequently surface catchments now provide only one-quarter of the demand of the integrated water supply scheme that supplies Perth, Mandurah, Kalgoorlie and the northern wheatbelt, as against over 80% during the 1970s.

The observed reductions in streamflow are mostly due to a change in rainfall patterns and intensity, with a later start to winter, fewer rain days and less rain each rain day. Prior to 1975, droughts did occur but were balanced by above-average inflows about once in three years. During the past 30 y, no above-average inflow has been recorded.

While there are sound data pointing to a detrimental shift in climate for this part of Australia, I believe that changes to forest management practices are also playing a significant role. Hence it is argued that the state must respond by considering alternatives designed to better conserve soil water, and to increase stream flow.

Forest management practices

A number of current forest management practices have a negative effect on streamflow. These include:

- The Conservation Commission's 2004-13 Forest Management Plan requirement that all streams have an undisturbed buffer ranging from 30 to 100 m wide to benefit water quality and biodiversity. While their value in this regard is recognised, these near-stream 'source areas' generate most of the water yield. Maintaining phreatophytic vegetation with ready access to water increases transpiration and reduces streamflow.
- The Forest Management Plan direction that Fauna Habitat Zones be established to allow re-colonisation of areas disturbed by mining, dieback, logging and thinning. These areas may be prescribed burnt but will not be logged or non-commercially thinned for 20–30 y.
- Bauxite mining by Alcoa World Alumina that covers up to 25% of some forested water catchments. Mining has removed the bauxitic profile and this in turn has altered the hydrology — by increasing vertical drainage and reducing interflow. In addition, the rehabilitated mine-pits have been engineered to retain water to reduce turbidity.
- The successful rehabilitation of mined areas by Alcoa with exotic and native species. Unfortunately the high seedling density and lack of widespread thinning or burning has resulted in stream flows that are now lower than those prior to mining. Alcoa is also required to plant adjacent dieback-affected areas with shrubs and tree species. While in many ways this is a desirable practice, dieback-affected areas have been shown to provide a high yield of water.
- The extended duration of the average prescribed burning cycle — roughly doubling from about 5–6 y in the 1970s to 10–12 y in recent times (Department of Environment and Conservation (DEC), *pers.comm.*). Prescribed burning temporarily reduces the litter and understorey layers, thus benefiting water yield for 1–2 y after a burn. In addition, DEC has reduced burning of stream and wetland areas known to contain populations of the mainland quokka.

Management options to increase streamflow

Options to increase water yields from forested catchments include commercial logging, follow-up non-commercial thinning of regeneration to maintain basal areas between 10 and 18 m^2 ha^{-1}, control of coppice and more frequent prescribed burning. While all these options are politically sensitive, forest treated in these ways will have access to a considerably greater amount of water (possibly as much as 200–400 mm, that is, 200–400 L m^{-2} or 2–4 ML ha^{-1}) than untreated forest, including that within national parks and reserves.

Figure 1. This is a well-managed jarrah forest that provides multiple benefits. It has been logged three times (before 1920, in 1940–1950 and in 2007), it has provided water for Perth since 1911, it has been protected by prescribed burning and it contains threatened species such as the chuditch, quokka, woylie and cockatoo. In 2006 the forest was thinned from 45 to 12 $m^2 ha^{-1}$ (550–110 stems ha^{-1}) by the Forests Products Commission. The marked trees are to be retained as habitat trees.

Some of this water will be used by the remaining trees and understorey for growth and some will be evaporated from the litter — but some will infiltrate into the soil, where it will improve soil-moisture storage, cause water tables to stabilise or rise, and provide additional streamflow.

The extra water available will benefit aspects of biodiversity in both aquatic and terrestrial ecosystems, and forest health, as well as provide water for human use.

What may happen to the areas with conservative management?

Some conservation 'champions' believe that intervention by foresters and catchment managers is undesirable and that the forest, if left alone, will fix itself. We need to ask, however, what may happen to those forests where silviculture is excluded should rainfall continue to decline for, say, another decade or possibly longer:

- Water tables will continue to fall, soil moisture stores will be depleted, and streamflow will decrease. Some parameters of water quality may change for the better (salinity may fall), others for the worse (pollutants may become more concentrated).
- Perennial streams will cease to flow for a period each year, and annual streams will flow for shorter periods. Stream biodiversity will become less complex and those species that require perennial flows will disappear.
- Tree growth will decline further. Data collected during the 1960s to 1980s suggests that the onset of competition begins at a stand density of about 20–25 $m^2 ha^{-1}$ in the 1000–1100 mm y^{-1} rainfall zone. This threshold will be lower with lower rainfall.
- Trees have developed multiple strategies to cope with both climatic change and attack by insects and fungi. The process is often a dynamic one: tree crowns may decline, partially recover, and then be affected once again. In other cases there can be rapid collapse of a whole stand of trees. This is often observed on shallow soils, for example near rock surfaces. There were obvious examples of this in the jarrah forest during autumn 2007 following the dry preceding winter, and a progressive increase in the incidence of unhealthy and dying jarrah can be expected.
- An extended dry period within the jarrah forest will favour a shift to more hardy, drought tolerant plants, and to different suites of insects and animals dependent on those plants. While jarrah does grow in lower-rainfall areas, it is more open, lower in height, smaller in girth and has a lower basal area. Moreover, regeneration will be less abundant and seasonally more variable, and jarrah may be gradually replaced by other species. Significant shifts in plant populations over a 30–40 y period have already been documented for the Swan Coastal Plain and may also occur in the jarrah forest.

Where a state accepts that the present phase of declining rainfall is associated, at least in part, with greenhouse-related global warning, it should be looking to policies and strategies that minimise the impact of these events on environmentally sensitive forests and related streamflow. The Government of Western Australia has accepted this challenge by approving a catchment-wide trial in 2005 in the 13 000 ha Wungong catchment where about 60% will be silviculturally treated to increase current flows by an estimated 4–6 GL y^{-1} or about 25% (www.watercorporation.com.au/wungong).

All Australian foresters might review the condition of the forests they have worked in and cared for, and advise governments on practical management options to mitigate any detrimental effects of climate change.

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