Wungong Catchment Trial

Vegetation dynamics and water yield under changing climate and management

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Water Corporation

Vegetation dynamics and water yield under changing climate and management
Water Foundation Project 041 05

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The work is undertaken by a team of scientists and technicians notably: Kevin Petrone, Craig Macfarlane, Jeremy Wallace, Warrick Dawes, Santosh Aryal, Trish Lambert, Natalie Smart, John Byrne, Chris Johnstone, Tom van Niel, Justin Hughes (ALCOA), James Croton (WEC), Amanda Reed (Water Corporation), and advice received from Keith Barrett (Water Corporation), Frank Batini, and Richard Boykett (DEC) and Robin Smith (Dept of Water)

Abstract
Over the last thirty years stream flows have declined by over half in the forested catchments of the Darling Plateau. How much of the decline in streamflow is due to the change in rainfall quantity and intensity, and how much due to vegetation adaptation to the current climate or to forest condition and management is of critical importance in developing appropriate management practices for these catchments that supply the cheapest water resource for Perth and the Goldfields and meet 25% of the Integrated Water Supply Scheme needs. The Water Foundation project aims to determine how much of the decline in stream flow is due to changes in climate and how much to the forest condition and forest management. The project combines intensive field monitoring with a field trial of thinning, large scale data integration and analysis, physical catchment modelling and systems modelling. Improved understanding will enable simulations of forest manipulations to be made and explore the possible water and ecological outcomes. Results show that in addition to the decline in the mid 1970s, runoff coefficients have declined further since 2000, and even with similar rainfall to earlier years catchments now deliver less water to streams. There is a close relationship of runoff coefficient to forest density and average tree age. This is probably because the water consumption of the forest is much more closely related to sap wood area than basal area, which is the traditional foresters' measure of forest density, and sapwood area is a much higher proportion of basal area in young forest than in old. Results from field observations, data analysis and physical modelling are being included in a systems model of the forested catchments so that management scenarios can be tested for their impacts on water yield and environmental conditions as well as timber yield.

Methodology
The project focuses on catchments not affected by mining and has three major components, firstly, large scale statistical analysis of data sets, from 40 catchments through the last 20 years, to establish the relationships between streamflow and the major environmental drivers such as annual rainfall, temporal distribution of rainfall, catchment characteristics, and forest disturbance due to fire or logging (Wallace et al., this meeting). Secondly, an intensive field study monitors catchment soil moisture status, groundwater levels, streamflow, and forest water balance in three small catchments. Two of these are being thinned in transects and our measurements will show us what the effect on the water status is likely to be and help constrain and improve the modelled outputs. The different water use characteristics of old and young trees, on trees in thinned forest and the relationship between forest architecture and water use will be determined by these measurements (Macfarlane et al., this meeting) and inform the third, modelling, component of the project. Computer modelling of catchment runoff generation and response to climate and management enables us to examine our field measurements in more detail, and place point scale measurements in a catchment context. This modelling includes a dynamic vegetation module that will enable representation of a vegetation canopy responding to climate and management scenarios which will enable us to explore forest management options for water and wood yield. Finally, the knowledge gained by these three components is being encapsulated in a system model of catchments with managed forest so that economic and environmental scenarios can be included in an assessment of management interventions that will impact on water and wood yield.

Results
Cumulative rainfall deficit (FAO56 (Allen et al., 1998) reference evaporation minus rainfall) indicates a continual drying of these catchments over the last two decades. Throughout many catchments on the Darling Plateau groundwater levels in native forest are falling (Figure 1). As the groundwater drops below the stream zone the connection with streamflow diminishes and baseflow declines and generation of saturated source areas also declines.

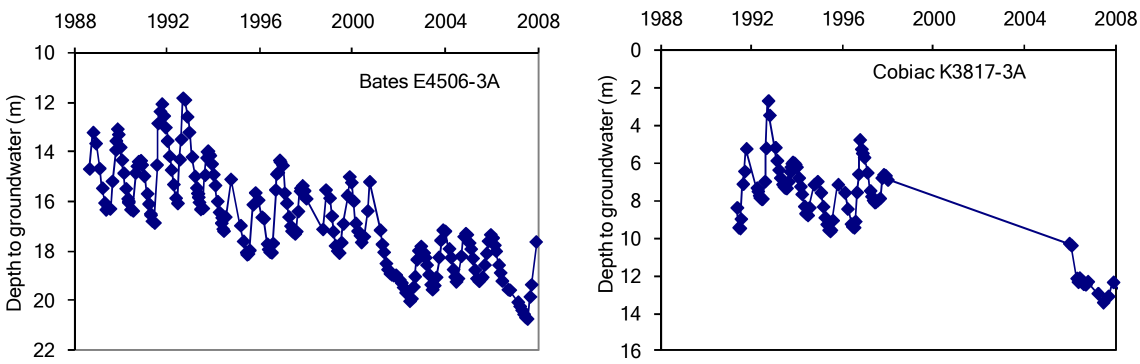

Figure 1. Groundwater levels in two forested catchments in the Darling Range

Examination of the relationship between groundwater in the near stream zone and runoff coefficient shows a strong relationship with declining runoff as watertables decline. Runoff coefficients are falling, though rainfall is not declining further, or not significantly (Figure 2), since the year 2000. Even in years with similar rainfall, since 2000 less streamflow is being generated. Statistical analysis of annual rainfall and "heavy rain days" (>30 mm) and streamflow has found "change points" in the runoff series around the year 2000, but no commensurate change in rainfall. This suggests that more than simply climate change is impacting on flow, even in catchments previously thought less affected by the new climate regime (such as Waterfall Gully).

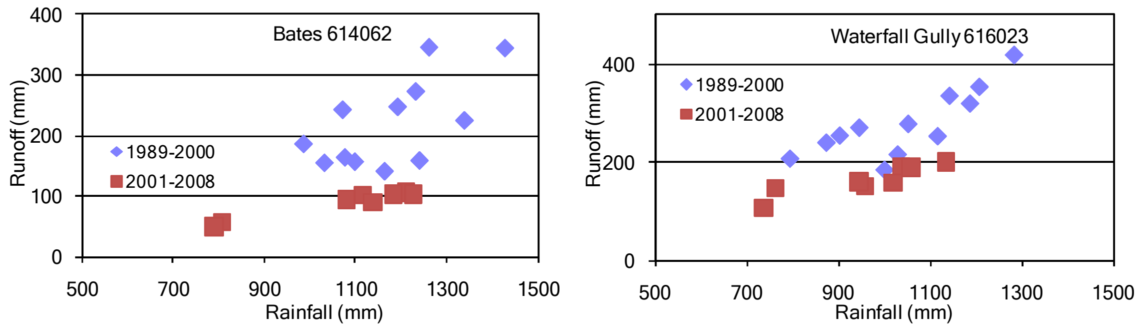

Figure 2. Annual runoff plotted against rainfall in two forested catchments in the Darling Range

In developing a coupled timber and water balance model the principle response of a complex many parameter model linking tree transpiration with leaf area growth has been condensed into a two parameter model that can be coupled to any water balance model that calculates vegetation transpiration. This, in combination with relationships between wood growth and water use based on the development of sapwood area rather than basal area are being combined into a "system model" of forested catchments that includes economic and environmental measures will assist exploration of the impact of forest manipulations on forest condition, growth, structure, environmental flows and water yield. This model is expected to be tested within the next few months.

Conclusion

Forest condition clearly has an impact on runoff. We have manipulated the forest into its current condition and this is one of the few management levers we have to influence its condition in the future. We must develop sensible management aimed at ensuring the resilience of the forest ecosystems to adapt to future changes, be they climate or otherwise, and maximising the overall benefit of the catchments as a combination of timber, water and biodiversity. This will be best accomplished with an understanding of the relationship between forest structure and all catchment values if we are to ensure future viability of these resources.

References:

Allen R.G., Pereira, L.S., Raes, D., and Smith, M., 1998. Crop evapotranspiration: guidelines for computing crop water requirements. Food and Agriculture Organization of the United Nations, Rome.