

Review of “Where to locate a tree plantation within a low rainfall catchment to minimise impacts on groundwater resources.

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General comments

This manuscript describes a paired catchment study in southwestern Victoria that examines effects of a young eucalypt plantation on groundwater recharge when compared with pasture. The topographic and ephemeral stream controls on groundwater recharge at the study site lead the authors to recommend future tree plantations to be situated in topographically high parts of catchments where recharge is already low, if relatively high water use by plantations over pasture is the primary concern.

At a high level, however, it appears that the general concept of this study has not been well thought out. Tree plantations (with *E. globulus*, as in this study) are generally established with one objective being to provide products (pulp or timber in the case of *E. globulus*) for economic benefit. The close link between tree growth and water use means that locating trees in areas where water use is lower (as suggested in this study), will lead to reduced growth rates, and go against what is likely to be the main objective of the plantation. No plantation manager will plant this species with an objective to reduce its water use – in fact quite the opposite. Plantation managers generally seek out parts of the landscape where soils are deep (>3m) and where water availability is relatively high – because the primary objective is to maximise growth. The concept of this study lends itself more to establishment of more drought tolerant species for purposes other than direct economic benefits, such as aesthetic or biodiversity values.

The manuscript represents a reasonable contribution to understanding of the processes of groundwater under tree plantations, and it is within the scope of HESS, but there are several issues that need to be addressed before publication is considered. The presentation of the manuscript is generally good, and suggestions made below will help improve it.

Specific comments

1. Reading the title, my expectation was to find a study that included some plot based measurements of the land uses in question, so that the effects of these on below ground hydrology can be clearly shown. I would have expected to see some measurements of plantation and pasture, or at least some measurements of soil moisture below these so that observations from above (rainfall) and below (groundwater) could be directly linked to the change in land use. As it turns out, the observed differences in groundwater behavior are attributed to the different landuses without any direct evidence to support this.
2. Absence of calibration data - the study is based on a paired catchment method. The usual to this is to undertake a period of calibration for some time (several years) during which streamflow in both catchments is recorded before the treatment (ie. plantation establishment in this case) is imposed on one catchment. No two catchments are the same, and therefore a period of several years of calibration is generally required in order to separate effects of catchment characteristics, and to allow quantification of the differences associated with land use. How can we be sure that the observations are largely due to vegetation cover and not due to differences in catchment size (one of the catchments in this study is twice the size of the other), topography, soils or geology? The absence of calibration data means there is no control for separating vegetation effects from landscape effects. Is the reduced streamflow entirely due to effect of the plantation in increasing ET? Is the reduced recharge estimated in the eucalypt catchment directly related to the presence of trees (which has been assumed) or due to differences in topography, soil and hydrogeology between the locations at which recharge was estimated?

3. It is interesting that no mention is made of the relative ET of eucalypt plantations compared with pasture. This is after all the driving force behind the observations made in this study. At the very least, some reference to the differences in ET could be made, possibly with estimates made using equations by Zhang et al 2001 (Zhang, L; Dawes, WR; Walker, GR (2001) *Water Resources Research*, 37: 701-708). Note that these relate to closed canopy forests.
4. p. 10006, line 8: The runoff ratios for the two catchments (not sure over which period these have been calculated) suggest that long term runoff for the pasture and eucalypt catchment are 22.8 and 28.8 mm/yr. So, long term runoff from the eucalypt catchment is some 26% higher than that of the pasture catchment. This raises the question as to how similar the catchments really are, and reference to this should be made.
5. p. 10008, lines 13-14: There are 2 small dams in each catchment. At least one dam in each catchment appears to be close enough to the weir that it would affect observations of streamflow. Justification as to why this might not the case would be useful.
6. p. 10008, lines 14-17: It is assumed that the roads have little or no impact on hydrology because they occupy a small surface area. However, the low permeability and connectivity of unsealed roads could affect the runoff processes in the catchments. I've been in native forests, where little if any overland flow occurs, yet water still flows in roadside culverts. These roads can directly connect with streams at river crossings. Due to the low rainfall at this site, it may well be that the roads have little impact on streamflow. If no visible signs of road generated runoff occurred during the winter months in the study catchments, then this would suggest the roads had little impact. Please provide more detail.
7. Trees were planted in July 2008, and measurements were taken from Aug 2009 until Feb 2013, equating to a plantation age of 1 to 4.6 years. The study by Forrester, D. Collopy, J and Morris J. (2010). *Transpiration along an age series of Eucalyptus globulus plantations in southeastern Australia. Forest Ecology and Management* 259 (2010) 1754–1760) shows that leaf area index and transpiration are still increasing at this stage, and tend to peak at around 6 years of age. It is likely that ET from the young plantation, at least in the first 2 years, was not much different to that of the pasture. The study should make reference to the age of the plantation during the course of this study to place it into context.
8. The plantation is considered as a homogenous land use with no mention of variation through space and time. It is surprising that no measurements within the plantation itself were made in the course of this study. While suggesting that planting trees in upslope areas may reduce impact on groundwater recharge, it is likely to also result in reduced water use and reduced growth rates. It would have been interesting to relate the conclusions of this study to the development of trees in these areas. For example, relatively simple measurements of tree diameters and heights in a few upslope and downslope plots at different times would have provided an estimate of differences in growth rates and tree mortality (ie the stand density will be lower at 4 years of age than it was at planting), as well as providing some indirect evidence of water use between upslope and downslope areas.
9. The area covered by plantation in the eucalypt catchment is 60%, while there is also some forest cover in the pasture catchment (the % area is not given), but appears to be about 10% according to figure 2). So, the difference between the two catchments in terms of tree cover appears to be about 50%.
10. I strongly recommend placing this study in context with reference to “A review of paired catchment studies for determining changes in water yield resulting from alterations in vegetation”. AE Brown, L Zhang, TA McMahon, AW Western, *Journal of hydrology*, 2005.
11. Figure 10 – The caption is a little misleading as it suggests that the two blue lines represent the change in watertable over the course of the study. However, fluctuations in Figure 6 show that the water table fluctuates annually, and the start and end dates used in Figure 10 are in winter 2009 and summer 2013

respectively. If comparing watertables from winter 2009 to winter 2012, or from summer 2010 to summer 2013, the levels may look somewhat different.

12. p. 10015 lines 5-10 and Figure 7. The text and caption refers to the effect of streamflow on groundwater. Shouldn't it more logically refer to the effect of groundwater on streamflow?
13. The conclusion of the study is that to limit the effect of plantations on reducing groundwater recharge, one should locate plantations in upland areas – where less recharge could be intercepted. This presents an interesting conundrum, because these plantations (and certainly in the case of the species studied here) are established with a product (usually pulp or timber) in mind with some economic benefit. The species used here, *E. globulus*, would generally not be planted in areas with rainfall <600-650 mm/yr. So, locating this species in the relatively drier parts of the catchment where they use less water is pushing them to their limit. Limiting access to potential recharge (soil) water to reduce water use also increase mortality and reduce tree growth – and will increase the chance of the plantation being economically unviable. The story is different of course if species more adapted to low rainfall environments, with benefits other than those related to biomass yield (e.g. aesthetics, biodiversity), are selected. So, the objectives of any plantation establishment need to be identified. These will generally not be limited to one objective alone, and decisions by plantation managers will be based on a number of competing objectives, with a major one being to maximise growth.

Technical corrections

1. Please define what is meant by dry region (eg. p. 10002, line 17) by specifying annual rainfall. 'dry' means different things to people in different areas.
2. The catchments are generally referred to as the pasture and eucalypt catchment (which is fine) but in some case are referred to by other names such as farm and plantation catchments (p. 10006, Line 8). Please be consistent.
3. I suggest using the word 'estimate' rather than 'estimation' in the manuscript
4. The term 'south-eastern' (for example) should be used rather than 'south-east' when referring to a region. (eg. p. 10004, line 7). South-east refers to a compass direction.
5. Please provide sub-headings for the site description section (2.1). Descriptions of catchment geology/topography, climate, vegetation, and bore installation can be separated to make it easier for the reader to navigate.
6. Figure 1 can easily be removed.
7. Figure 2 could be incorporated into Figure 2.