**Anonymous reviewer 3**

We would firstly like to thank the reviewer for their constructive comments on this manuscript, and for taking the time to provide such a detailed review. We have responded to each main and specific point individually, as well as technical corrections where appropriate. All alterations arising from this review have been made in the final manuscript that we will submit to Hydrology and Earth System Sciences for consideration for publication. Here we respond to each paragraph in the order that they are written in the original reviewer comment, and address each point as numbered in the review.

**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.

We have responded to these comments under point 13 below.

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 behaviour are attributed to the different landuses without any direct evidence to support this.

This study was proposed from a hydrogeological perspective and as such the primary purpose was to observe the effects of the tree plantation on groundwater resources using a comprehensive hydrogeological study, rather than an ecological approach. We acknowledge that the title may be misleading in this regard and have therefore changed it to better reflect the groundwater point of view that informs this study:

"A groundwater recharge perspective on locating tree plantations within low rainfall catchments to limit water resource losses."

Plot based measurements were carried out for hydrogeological data, and soil moisture data was also collected. The overall results showed the expected effect of drier soil beneath the plantation, but unfortunately instrument failure during the study period severely compromised that data so these are not included.

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?

Unfortunately a calibration period was not carried out, as the main study commenced after the trees were planted in the eucalypt catchment. However, some hydrogeological data exists in both catchments prior to the trees being planted, and this shows that the two catchments behaved very similarly before the study began (Figure 6). We feel that the hydrogeological data obtained during this study (particularly the CMB and long term WTF results) strongly supports our assumption of the hydrologic differences being the result of the modern land use change. Our data also show that any differences in geology/soil/landscape between the catchments are very small. The text has been modified to make these points clear.

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.

We have made detailed estimations of ET in both catchments and these will be presented in a paper which is about to be submitted. For the sake of brevity and to keep to the specific aims of the present paper, we have omitted a discussion of ET (the aims have been altered to better reflect this). We will incorporate ET estimates from the Zhang Curves in the forthcoming paper on the area. However, we would point out that these curves tend to overlap as mean annual rainfall decreases below 700mm, as in this study.

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.

The runoff ratios were calculated over the study period (i.e. since the plantation was established); this has been added to the text. The streamflow dataset has since been corrected for issues with the weir gauge earlier in the study period and the recalculated runoff ratios are 3.0% and 3.3% for the eucalypt and pasture catchments respectively. These values have been updated in the text.

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.

The dams are very small, with a total area no greater than 0.0001 $km^2$ in both catchments (0.0001-0.0002% catchment area), and are not to scale on figure 2. They have a very limited effect on streamflow; field observations showed that flow in the stream was not delayed by filling of the dams. The text has been modified to make this clear.

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.

There is some runoff generated on the roads as would be expected, but the vast majority of overland flow is readily observed to flow in the stream channels and not along the roads. The streams flow consistently above the points where the main road in the area crosses the channels in both catchments. A statement to this effect has been added to the text.

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.

We agree, and this point has been addressed in the text.

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.

Due to the hydrogeological approach of this study, such measurements were not carried out, although we admit that they would have been useful. We hope that the clarification of this point and the alteration of the manuscript title will alleviate concerns over the lack of vegetative measurements to determine differences in tree growth and water use between upslope and downslope areas. We have added more discussion on how the groundwater hydrographs (figure 5) change through time as the plantation ages.

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 term of tree cover appears to be about 50%.

Figure 2 (and others) overestimate the area of tree cover in the pasture catchment (it is closer to 6%; this has been made clear in the paper), and the tree cover in the plantation catchment is closer to 76%

( a previous lower figure was due to conflicting data from the forestry contractor, and has been corrected).

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.

This is an excellent point, and we have incorporated a discussion of this into the final manuscript.

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 using 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.

We thank you for pointing this out, and the figure has been altered to show water tables from winter 2009 to winter 2013. This makes little difference to the shape of the two lines, and the conclusions drawn from comparing one part of the landscape to another remain valid.

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?

At the study sites the streams are all losing streams, so they lose flow to the groundwater (except under certain conditions at the downstream ends of the catchments; figure 8). The main conclusion of the manuscript is that recharge predominantly occurs along drainage lines and where overland flow is concentrated into lowland areas. Figure 7 shows this link between flow in the stream and groundwater recharge, indicating that recharge readily occurs through the losing stream and in the directly adjacent lowland areas.

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.

These are valid points and were not previously considered directly in the discussion, which was rather presented from the sole perspective of preserving groundwater recharge. These points have been added to the discussion to show that while moving the eucalypts away from the main recharge areas in a catchment will help preserve groundwater recharge, it may not be a viable economic move.

**Technical corrections**

All technical corrections are accepted and alterations in the final text have been made, except:

7. Figure 2[3?] could be incorporated into Figure 2. We have incorporated Figure 11 into figure 2 to reduce the number of figures, while at the same time maintaining the clarity in both figures 2 and 3.