Comments from reviewer #2:

The likely effects of plantation expansion on streamflows in Australia is a current topic of interest to hydrologists, water resources managers and forest management agencies. Predicting the effects accurately is imperative and the authors in this paper have expanded on their work published in various other locations (e.g. Zhang et al., 2001; Brown et al., 2005; Zhao et al., 2010) largely by applying and testing the FCFC model in larger catchments.

In general the paper is informative and well-written. I do, however, have some comments:

1. Prior land use. There is no mention in the paper of the land use prior to afforestation. The reader unfamiliar with Australian forestry may well assume that the prior land use was grass or pasture. However, this is not always the case. Until the 1980s much of the pine plantation estate in Australia was established by the clearing of native eucalypt forest, i.e. a eucalypt to pine conversion (cf a grass to pine conversion). Examples verifying this include the Croppers Creek project in Victoria (Bren & Hopmans, 2007) and the Lidsdale project in New South Wales (Putuhena & Cordery, 2000): Bren, L.J. & Hopmans, P. (2007). Paired catchments observations on the water yield of mature eucalypt and immature radiata pine plantations in Victoria, Australia. Journal of Hydrology, 336: 416-429. Putuhena, W.M. & Cordery, I. (2000). Some hydrological effects of changing forest cover from eucalypts to Pinus radiata. Agricultural and Forest Meteorology, 100: 59- 72. This information is critical for the analysis and discussion of results. Figure 4 show cumulative plantation cover in the Adjungbilly Ck catchment, but given that the bulk of the expansion occurred in the 1960s and 1970s, was this eucalypt conversion or grass conversion? If it was wholly or partially eucalypt conversion, does this invalidate the results presented? Some further information and/or comment is warranted here.

Response: We agree with the reviewer that prior land use is important for understanding the results presented in the study. Hence we have provided more detailed information on prior land use in the selected catchments and this should help readers to understand the results presented in the paper (see as follows).

3.2.3 Plantation and land use data

In order to investigate the effects of plantation expansions on streamflow, plantation data including plantation area and age for each of the selected catchments were provided by the Bureau of Rural Science and State agencies. Plantation development began in 1935 in Adjungbilly Creek mostly on native forest sites. Since 1982, planting started on land previously occupied by pastures and cumulative plantation cover (%) over time for Adjungbilly Creek is shown in Fig. 4. The Batalling Creek catchment was 50% cleared for agriculture from 1940 to 1970 and plantations were established in the catchment in 1985 with eucalyptus covering 38% of the cleared area (Bari and Ruprecht, 2003). The Burnt Out Creek catchment is located in the western Mount Lofty Ranges, South Australia and around 40ha or 67% of the catchment was replanted with P. radiata in November 1978 after a bushfire destroyed most of plantation in the catchment (Greenwood and Cresswell, 2007). The Crawford River catchment has several main land uses including pastures, hardwood (blue gum: Eucalyptus globulus) and softwood (radiata pine: Pinus radiata) plantations, cropping and native forest. The area of plantations expanded significantly from less than 2000 ha in 1995 to 17,000 ha or 25% of the catchment area in 2005. The Darlot Creek catchment and Eumeralla River catchment experienced similar plantation expansions with most plantations established since 1995. The area of land under pine plantations in the Delegate and Bombala catchments expanded to 11% and 14% of the catchment area respectively (Tuteja et al., 2007). The Goobarragandra Creek catchment experienced plantation expansion in the period of 1965 to 1988 with about 8% of the catchment area planted. Plantation in the Jingellic Creek catchment did not start until 1965 and over 5000 ha of pasture land were converted to plantations in the period of 1982 to 1996, representing 14% of the catchment area. In 1986 and 1987 the entire Pine Creek catchment was converted from open grassland to Pinus radiata plantation (Linke et al., 1995, Lane et al., 2005). Red Hill is a small experimental catchment and over 70 % of the catchment was planted with Pinus radiata in 1988 and 1989 (Major et al., 1998). The Traralgon Creek catchment was 70% planted with Eucalyptus regnans from the late 1950s (Feikema et al., 2008). The Upper Denmark and Yate Flat Creek are sub-catchments of the Denmark River catchment. Clearing native forest for agricultural development in the catchments began in 1870 and 17% of the catchment had been cleared by 1957 (Bari et al., 2004). Tree planting in the catchments started in 1991 on previously pasture land (Bari et al., 2004) and by 2000 it had been almost completely replanted, mainly to E. globulus. Summary of the plantation data for the selected catchments is listed in Table 1. More detailed description of the plantation development in these catchments can be found in Zhang et al. (2010). Other information including land use history, farm dams, and water diversions was also obtained for the selected catchments. Over the period of streamflow records, these catchments had minimum impact from farm dams and water extractions, and plantation expansion represents the most significant land use change in these catchments.

References

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Bari, M. A., Mauger, G. W., Dixon, R. N. M., Boniecka, L. H., Ward, B., Sparks, T. and Waterhouse, A. M.: Salinity situation statement: Deanmark River, Water Resource Technical Series No. WRT 30. 2004.

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Tuteja, N. K., Vaze, J., Teng, J., and Mutendeudzi, M.: Partitioning the effects of pine plantations and climate variability on runoff from a large catchment in southeastern Australia, Water Resour. Res., 43, W08415, doi:10.1029/2006WR005016, 2007.

Zhang, L., Zhao, F. F., Brown, A. E., Chen, Y., Davidson, A., and Dixon, R. N. M.: Estimating impact of plantation expansions on streamflow regime and water allocation, Tech. Rep. 1835-095X, 84pp., CSIRO Water for a Healthy Country National Research Flagship, Canberra, ACT Australia, 2010.

2. Effects of plantation age and other factors. Some discussion of this needs to be added. Use of the FCFC model appears not to account for the "life cycle" of a plantation, with water use changing with forest age and thinning, for example. One of the catchments used (Red Hill) formed part of a paired catchment study that evaluated the effects of age and thinning on streamflow. The authors should refer to this work: Webb, A.A. & Kathuria, A. (2012). Response of streamflow to afforestation and thinning at Red Hill, Murray Darling Basin, Australia. Journal of Hydrology, 412-413: 133-140. Acknowledging that FCFC compares long-term means, one assumes, however, that there is a lag in FDC changes due to afforestation. Was it evident in any of the datasets? Some comment on this issue should be included. Was drought a factor given that post-planting in southern Australia has probably been drier than pre-planting?

Response: Thanks for the comments. We have added a new paragraph in the discussion section on effects of plantation age, thinning, and rainfall differences between the pre-treatment and post-treatment periods.

The detailed discussions are as follows.

It is known that plantation water use increases with its age till it reaches a maximum and this process is generally accompanied by increasing streamflow reductions (Scott and Smith, 1997). FCFC only considers two hydrologically equilibrium states of a catchment represented by pre-treatment and post-treatment vegetation covers. In other words, FCFC predicts changes in flow duration curves from pre-treatment equilibrium state to post-treatment equilibrium state. The equilibrium state is generally associated with a stable vegetation cover and climatic conditions. This assumption may not be strictly valid in some of the catchments used in this study due to uncertainty of plantation age, short pre-treatment flow data, and thinning. The time required from pre-treatment equilibrium state to post-treatment equilibrium state varies between 5 and 15 years for eucalyptus plantation in South Africa (Scott and Smith, 1997). Zhao et al. (2012) reported consistent estimates of plantation age effect on streamflow for catchments in Australia. Lane et al. (2005) investigated changes in flow duration curves in relation to plantation age and found similar results. These studies indicate that plantation age is an important factor in determining plantation impact on streamflow. For the catchments reported in this study, the pre- and post-treatment periods were selected to acknowledge the plantation age effect. For the small catchments such as Red Hill, plantation development took place in one stage and the post-treatment was chosen as 2001 to 2005, representing average plantation age of 14 years. However, for large catchments plantation took place in several stages over a period of many years. It is difficult to determine plantation age in these catchments. To minimize the plantation age effect, the post-treatment period was selected with relatively mature plantation cover. Apart from plantation age, management of plantation such as thinning can also affect streamflow. Webb and Kathuria (2012) showed that thinning of the plantation in Red Hill in 2003 had a noticeable effect on streamflow. These factors would affect the accuracy of FCFC predictions. Another important factor in estimating plantation impact on streamflow is rainfall and in general the post-treatment period was drier than the pre-treatment period. FCFC incorporated this effect by using average rainfall during the post-treatment period for each catchment.

References

Webb, A. A. and Kathuria, A.: Response of streamflow to afforestation and thinning at Red Hill, Murray Darling Basin, Australia, J. Hydrol., 412-413, 133-140, 2012.

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Scott, D. F. and Smith, R. E.: Preliminary empirical models to predict reductions in total and low flows resulting from afforestation, Water SA, 23(2), 134-140, 1997.

3. Comparison between predicted and observed FDCs. The authors state (p388) that "all the catchments showed good agreement between the predictions and observations, except for one or two other catchments". While this is supported by the coefficient of efficiency >0.8 there appear to be more than "one or two" exceptions. Upon inspection of Figure 7, the FCFC model appears to have performed least well in Bombala River (_27% plantation), Crawford River (24%), Darlot Ck (13%), Eumeralla River (20%), Red Hill (78%), Traralgon Ck (58%). Bombala R and Traralgon Ck do not seem to match up well at all and it would be useful for the authors to explain more explicitly where and why the predictions were more or less accurate. The inaccuracies do not seem correlated with catchment area or % plantation so what do the authors think is the cause?

Response: Changes have been made to explain causes of poor model performance in the Bombala River and Traralgon Creek catchments. A closer examination showed that the bucket model of the FCFC methodology did not capture the low flows well in the calibration phase. The bucket model overestimated the number of zero-flow days. The impact of this is that the model overestimated the high flows to compensate for the lack of flow flows so that a mass balance can be achieved. This indicates the importance of assessing the bucket model fit during the calibration phase of FCFC to ensure the low flows are being adequately modelled.

The detailed explanations in 4.3 are as follows.

4.3 Comparison between predicted and observed FDCs

Fig. 7 shows comparisons between FCFC predicted and observed FDCs for the selected catchments in the post-treatment period. Table 3 provides a summary of results for all the catchments. It is clear that most catchments showed good agreement between the predictions and observations. The model underpredicted the cease-to-flow (CTF) percentile or overestimated the number of zero-flow days in several catchments, for example, the predicted CTF is 48% for Yate Flat Creek, while observed value is 67%. However, the model overpredicted CTF in Red Hill. In 13 of the 15 the catchments the direction of change and the shape of the predicted FDC are consistent with the changes observed between the pre-treatment and post-treatment conditions. For the Bombala River and Traralgon Creek catchments, the predicted change in the FDC is not consistent with the observed change in shape between pre- and post-treatment condtions. Investigation into the causes showed that the bucket model of the FCFC methodology is not capturing the low flows well in the calibtation period. This results in an overestimation of the number of zero flow days or underestimated low flows. The impact of this is that the model overestimated the high flows to compensate for the lack of flow flows so that a mass balance can be achieved. This indicates the importance of assessing the bucket model fit during the calibration phase of FCFC to ensure the low flows are being adequately modelled. There is a strong correlation between predicted and observed median (see Table 3). The results in Fig. 7 and Table 3 show that the FCFC model works well with 13 of the 15 catchments having coefficient of efficiency greater than 0.8.