Thinning of rehabilitation increases stream yield in a mined catchment

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Background and aim

Monitoring of catchments in the high rainfall zone of the jarrah forest that have been mined for bauxite and rehabilitated show that stream flows initially increase, then decline below pre-mining levels (Croton *et al.,* 2005, Croton and Reed, 2007). Thinning of rehabilitation may be an option to manage water yield declines in mined catchments, but the magnitude and duration of any response to thinning is unknown. A study has been in progress since 2007 with the aim of quantifying the stream flow response to thinning of rehabilitation in a mined catchment.

Methods

Sites
The experiment is being conducted in Warren and Bennett's experimental catchments, located approximately 20km north of Dwellingup in the high rainfall zone of the Darling Range. About half of the catchments, each approximately 80ha in size, was mined in the late 1980's and rehabilitated over a three year period from 1990-1992. Rehabilitation coincided with early efforts at direct seeding and tree establishment rates represent the higher end of stand densities in Alcoa's rehabilitation. Stream flow in these catchments has been monitored since 1978, peaking at >500mm during mining followed by steady declines. The lowest recorded flows in both catchments (22-32mm) occurred in 2006, a year of very low rainfall. Groundwater monitoring is limited but indicate depths to water of 4-10m below surface.

Catchment treatment and vegetation monitoring
Rehabilitated areas within Bennett catchment were thinned (from below) by notching in April 2007, with a target stocking of 500 stems/ha. Due to initially high stockings, the target was not attained and a follow-up notching treatment was applied in September 2008. A relatively cool prescribed burn was undertaken in both catchments in November 2007, removing most of the understorey layer. Tree measurements were collected in 19 plots, 20m x 20m, located across both catchments in the three ages of rehabilitation and in unmined forest. Leaf area index (LAI) was also monitored using cover photography. Assessments were made prior to treatment in January 2007, and following the prescribed burn in January 2008. Tree measurements were repeated in thinned plots in January 2009 and LAI in all plots in August 2009.

Analysis of stream flow
Differences in monthly stream flow between Bennett and Warren due to treatment were investigated by a paired catchment analysis similar to that used by Watson *et al.* (1991). Stream flow data were supplied the WA Department of Water, but flow for the period January to August 2009 is presently unverified and should be treated with caution. The initial model of Bennett flow using Warren flow as a predictor was based on 30 years of record (1977 – 2006 inclusive), that included periods of mining and rehabilitation. A linear mixed model was utilised that accounted for seasonal differences in stream flow response and auto-correlation in stream flow data. Thinning effects in the post-treatment period were assessed to be the residual between observed and predicted flow in Bennett catchment.

Results

Prior to treatment, rehabilitated areas were typically densely stocked (mean 2700 stems/ha, max. 6200 stems/ha) with high stand basal areas (mean 32.2 m^2/ha, max. 51.4 m^2/ha) and elevated LAI (mean 1.8, max. 2.3). Unmined forest areas was variable due to the impacts of dieback, with generally lower stocking (mean 800 stems/ha) and LAI (mean 1.4), and an average basal area of 39 m^2/ha. Thinning in Bennett's catchment reduced stand basal area in rehabilitation to 23.7 m^2/ha initially, and to 14.8 m^2/ha after the second treatment. LAI in treated areas decreased to approximately 1.1 after the first thinning and prescribed burn, but by August 2009 – around 12 months after the second treatment – LAI had recovered to an average of 1.5. LAI in untreated rehabilitation and unmined forest over the monitoring period increased at a rate of 0.1-0.3 /year.

Significant (at $p < 0.05$) stream flow increases were detected in Bennett's catchment from the first year after treatment. Significant increases were observed in July and August 2007, in June and July 2008, and in July and August 2009. Total stream flow increases due to thinning were estimated to be 31, 31 and 35mm for the years 2007, 2008 and 2009 respectively, noting that the response in 2009 could be higher as the record is incomplete.

Discussion

Stream flow response to thinning of 31-35mm in this study is consistent with other similar studies reported for unmined catchments. Stoneman (1993) showed an annual average increase in stream flow of 33mm over a 9-year period in the Yarragil 4L catchment after basal area was reduced by two-thirds from 35 m^2/ha to 11 m^2/ha. The small and prolonged response, relative to other eucalypt forest catchments, was attributed to the large soil store characteristic of jarrah forest catchments and a relatively slow recovery in LAI. Similarly, heavy thinning of Hansen's catchment (35 m^2/ha to 7 m^2/ha basal area) resulted in increased streamflow of 40mm in the first year (WAWA, 1987). The larger increase compared to Yarragil was attributed to shallower groundwater prior to treatment.

Response in both stand basal area and LAI to thinning in young rehabilitation stands is known to be rapid (Grigg and Grant, 2009), and particularly so where treatment is relatively moderate as is the case here. The apparent early recovery in LAI of treated areas in this study could therefore indicate that stream flow increases may be comparatively shorter than in other jarrah forest catchments. Monitoring of stream flows is ongoing, but future vegetation monitoring will include more frequent assessments of canopy and understorey LAI to obtain a better understanding of temporal dynamics of LAI in unmined forest in addition to treated rehabilitation stands.

Conclusion

Thinning of rehabilitation can be used to increase stream flows in mined catchments. The magnitude of flow increases is consistent with those reported for other thinned but unmined catchments in the jarrah forest. Ongoing monitoring will focus on the longevity of the thinning response.

References

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