Are low flows affected by vegetation change in the same way as annual yield?

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The impact of tall vegetation on water yield is well established, although the amount of change is not always directly predictable. The primary cause of lower water yields from catchments with tall vegetation is through increased rainfall interception leading to less water available for streamflow. The higher rates of rainfall interception are caused by the greater leaf area of trees and scrub compared to pasture and the increased aerodynamic roughness that allows greater turbulent mixing of air above the canopy, and hence efficient removal of the evaporated water. Studies have reported reductions in average annual water yield following afforestation of between 20-50%. The amount of reduction varies between years and between sites.

There is far less literature on how low flows change following afforestation. Smith (1987) reports a reduction in low flows of less than the proportional reduction in annual yield for a comparison between forested and pasture catchments in East Otago. This is observable in the comparative flow duration curves for Berwick, which converge at the high and low flow ends and have the largest differences around the median flow range. However, Smakhtin (2001) cites six studies from around the world (including New Zealand) which suggest that following afforestation the percentage change in low flows is greater than the proportional change in annual yield,. Fahey et al (2004) point out that establishing a common low flow measure is difficult, especially in small catchments where the lowest flow may be zero. The conflicting messages in answer to the question posed in the title of this paper make it difficult for policy makers who are attempting to protect low flow values in streams. Recent work by Duncan (2003), in providing advice for the Environment Canterbury Natural Resource Regional Plan, has highlighted the paucity of data and knowledge in this critical area.

This paper re-examines data from four catchment studies in New Zealand in an attempt to answer the question posed in the title, using a variety of low flow measures. The data sets chosen represent a range of different conditions in New Zealand and also an increasing catchment size. Purukohukohu (0.34 and 0.23 km^2) is a long term paired catchment study that allows comparison between pasture and exotic forestry in the central North Island (Dons, 1987). The length of record allows comparison of the catchments before and after establishment of the forest. For the sake of this study the period following canopy closure (assumed at 10 years) was taken as a fully established forest cover. The Berwick suite of catchments (1.14 – 2.92 km^2) is a comparative catchment study in East Otago (Smith 1987) which lacks pre-treatment data so that a comparison can only be made by assuming the catchments have the same hydrological response. Glendhu (2.18 and 3.07 km^2) is a paired catchment study in Otago (Fahey & Jackson, 1997) that looks at the difference between exotic plantation and tall tussock. The treated catchment is not completely afforested (approximately 67%) due to a large wetland in the valley floor. Kakahu (2.75 and 4.55 km^2) is a paired catchment study in South Canterbury that compares exotic forest with a mixture of pasture and scrub. This data set was the most problematic to analyse with missing data and difficulties in distinguishing differences in the pre and post forest establishment.

For each catchment the flow duration curve was derived and Q95, Q90 and Q50 statistics derived. Annual yield and total summer yield (taken as December to March) were derived and low flow frequency analysis performed to derive the 7-

day low flows for an average recurrence interval of 1 and 5 years. The low flow frequency analysis in several cases was performed on short periods of data which limits the interpretation. Finally mean annual low flow (for 7 day duration periods) was derived.

The results show that each of the low flow statistics are affected in different ways (fig 1) and differ between sites (fig 2). In the majority of cases the low flows were affected less by afforestation than the annual yield. The exception to this was the Porukohukohu catchments which showed greater increases for Q95, MALF7day and the 7-day low flow with an average recurrence interval of 5 years. A small scale catchment like at Purukohukohu is dominated by hillslope flows that are probably more affected by vegetation change than larger catchments which have access to deeper groundwater for low flows. The influence of scale on low flows is an area that needs further investigation.

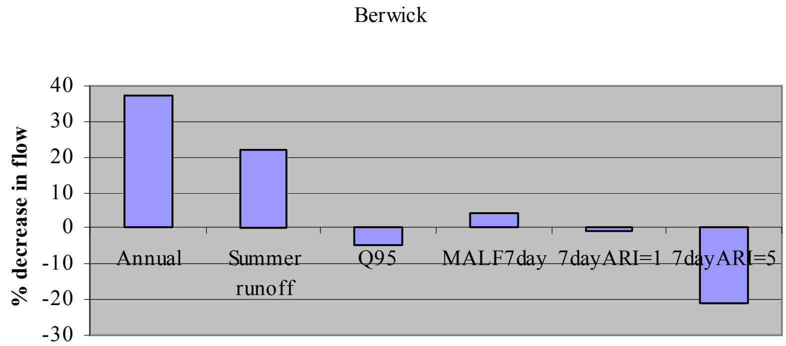

Figure 1: Percentage decrease in low flow statistics for the Berwick suite of catchments. N.B. A negative decrease equals an increase in the low flow statistic.

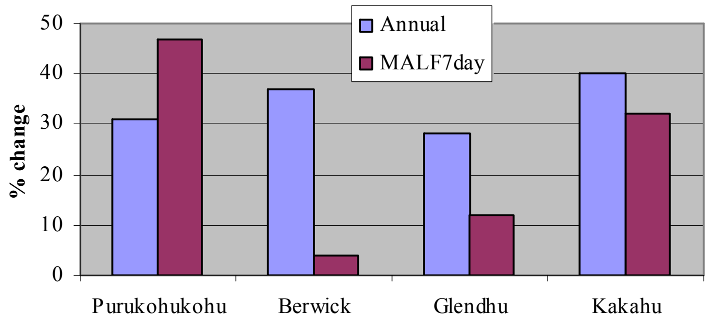

Figure 2: Percentage change in mean annual low flow (7 day duration) compared to change in annual yield.

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