

The effects of afforestation on low flows in various regions of South Africa

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Abstract

It may be expected that afforestation has the greatest relative impact on annual streamflow during the low flow periods prior to the first rains of the next season. A paired catchment approach was used to quantify the effect of afforestation with both pines and eucalypts on the low flows of five catchments in the winter and summer rainfall regions of South Africa. Dummy variable analyses were used to test the significance of afforestation on low flows during each year after treatment. Afforestation was found to have a highly significant effect on low flows in all five catchment experiments, with low flows being reduced by up to a 100% in some cases. The effect of afforestation generally appeared to be more marked for eucalypt plantings than for pines, and was manifest at an earlier stage after afforestation. For some catchments (Mokobulaan A and B) these differences became irrelevant as afforestation with both pines and eucalypts eventually caused the streams to dry up.

Introduction

Increased demands are being made on the limited water resources of South Africa as the population continues to expand (Department of Water Affairs, 1986). The demand for wood products, and consequently the rate of afforestation is also growing. Yet afforestation leads to a reduction in catchment water yield (Bosch and Hewlett, 1982; Van Wyk, 1987) so that there is a conflict between managing catchments for both sustained water and timber yields.

From a legal point of view, streams comprise both normal flow and surplus flow. By definition (the Water Act of 1956, Section 53), normal flow is that occurring with such a degree of dependability that it may be used beneficially for irrigation and other purposes without storage. The balance of the water in the stream is referred to as surplus water (Department of Water Affairs, 1986, p. 8.11). During the dry months of the year prior to the first rains of a wet season, normal flow is usually the only water remaining in the streams and it is referred to by hydrologists as low flow.

It is precisely at this low flow time of the year when in-stream water may be needed most critically. Consequently the impact of afforestation on these flows is of particular interest: the effect on low flows may be more important than the overall impacts on streamflow.

It has been clearly demonstrated that changes in vegetal cover may have marked effects on catchment hydrology and that these effects may manifest themselves at different times after treatment (O'Shaughnessy and Moran, 1983). Previous studies have established that afforestation causes reductions in low flows, or conversely that clearfelling of forests causes an increase in low flows. Mid-summer low flows in Jonkershoek in the winter rainfall region of South Africa were reduced by around 52% by complete afforestation with *Pinus radiata* (Banks and Kromhout, 1963). At Cathedral Peak, in the summer rainfall region, afforestation with *Pinus patula* caused reduced low flows, commencing some six to eight years after planting, and levelling off at around a 50% reduction (Bosch 1979). Silvicultural

practices did not have a notable effect on streamflow.

In the HJ Andrews Experimental Forest in Oregon, clearfelling and 60% partial felling of Douglas fir forest resulted in a greatly shortened low flow period for at least five years following felling (Harr et al., 1982). In Northern California, selective felling of coniferous forest led to detectable increases in low flow for the next nine years (Keppeler and Ziemer, 1990).

The Coweeta experiments in the southern Appalachian mountains showed that clearfelling forest doubled low flows in the late growing season when streamflow and soil water storage were lowest, but that it had little effect on flows in late winter and early spring when soil water was fully recharged (Swank et al., 1988). In the North-western USA the greatest part of the annual increases in streamflow following felling have been in the fall-winter rainy season, though the largest relative increases were in the summer (low flow) season (Rothacher 1970; 1971; Harr et al., 1979, cited by Harr et al., 1982).

This study quantifies the effect of afforestation, over time, on the low flow of several South African catchments in both summer and winter rainfall regions. This is the first detailed handling of low flows recorded in these catchment experiments. The hypotheses tested are:

- that afforestation causes a significant reduction in seasonal low flows; and
- that the effect is manifest much sooner in catchments afforested with eucalypt species than with pines.

Methods

The paired catchment approach

Four study sites were selected, one in the winter and three in the summer rainfall regions, as afforestation is concentrated in the summer rainfall regions of South Africa. Two of the summer rainfall sites, the Westfalia estate near Tzaneen (23°43'S, 30°04'E) and Mokobulaan situated southeast of Lydenburg (25°17'S; 30°34'E) are in the Eastern Transvaal, while the third, Cathedral Peak (29°00'S; 29°15'E), is situated near Winterton in the Natal Drakensberg (Fig. 1). The winter rainfall site is in the Jonkershoek Valley (33°57'S; 18°15'E), near Stellenbosch in the Western Cape (Fig. 1).

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