MANAGING RUNOFF FROM GRAZING LANDS

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ABSTRACT
There is a correlation between poor land condition and high amounts of runoff from grazing lands. The primary sources of sediment exported from grazing lands are hillslope, gully and riverbank erosion. Hillslope runoff has a large effect on all three erosion processes; by increasing the transport capacity of sediment from hillslopes to streams, increasing rates of gully and river bank erosion downstream. Improvements in pasture condition can be achieved through changes in land management over several years; however the time it takes to reduce hillslope runoff is less well documented. The quantity of runoff leaving two adjacent hillslopes on grazing lands near Mingela, Australia was monitored for 7 years. Both hillslopes were grazed for the first two years and then cattle were removed from one hillslope for the following five years. The annual runoff coefficients and the ratio of runoff between the two treatments was the same at the beginning of monitoring as at the end. This suggests that there has been insufficient time for hydrological recovery to occur five years after the complete removal of grazing.

INTRODUCTION

Growing evidence suggests that in certain areas, inappropriate grazing land management has resulted in increased sediment export from within the Burdekin catchment [Roth *et al* (2003), Post *et al* (2006)]. Almost all sediment exported from the Burdekin river catchment has been attributed to hillslope and gully erosion (McKergow *et* al 2005). Studies have shown how wet season spelling, better stock management, and riparian fencing can benefit both pastoral production and water quality by improving landscape function [Ash *et al* (2001), McIvor (1995), Scanlan *et al* (1996), Post *et al* (2006)]. There is however, limited understanding about the response time of infiltration following the implementation of improved pastoral management. Roth (2004) suggests that full recovery can occur after 15 to 20 years and that recovery must therefore begin sometime before then. While complete removal of cattle from the Burdekin catchment is not practical we will use this treatment as an end member to investigate the time of response.

METHODS

Study Site

The study site is located on Meadowvale station, near Charters Towers in Queensland, Australia. Meadowvale station has been used for cattle production for over 5 decades. The vegetation is dominated by Narrow-leafed Ironbark (*Eucalyptus crebra*) with an Indian couch *(Bothriochloa pertusa)* dominated ground cover. The major soil type is a red chromosol (Dalrymple series) overlying a Granodiorite substrate. This region has a pronounced wet season over the summer months, with most of the 660 mm of mean annual rainfall occurring between November and April.

Experimental Design

The experiment used four runoff troughs originally installed by Scanlan *et al* (1996) in the 1980's. The hillslopes were located approximately 500 m apart on the same ridgeline. They had similar slope and aspect with the troughs located at similar positions on each hillslope.

The four troughs (two per hillslope) were re-activated, calibrated and fitted with micro-loggers prior to the 2001 wet season. A tipping bucket rain gauge was installed on the treated hillslope. The control hillslope was grazed for the duration of the monitoring while the treated hillslope had grazing removed prior to the 2003 wet season. Both hillslopes had evenly distributed ground cover over the entire monitoring period with no large bare spaces between grass patches. The amount of ground cover varied seasonally and annually.

Data Analysis

Discharge for each trough was converted to runoff depth by dividing the total volume of runoff for each event by the catchment area. Event and annual runoff coefficients were calculated for each trough by dividing the total amount of runoff by the rainfall depth. The results from the two troughs in the same treatment were then averaged. Annual comparisons are made over water years, where 2006 is the water year 1 July 2005 to 30 June 2006. A comparison of total discharge, the ratio of discharge and runoff coefficients between treatment and control was used to determine if the removal of grazing led to a reduction in hillslope runoff over this five year period.

RESULTS AND DISCUSSION

Rainfall

Annual rainfall (Figure 1) was below the 100 year average for Charters Towers of 660 mm for all years. The lowest annual rainfall was 256 mm in 2003 which fell below the 10^{th} percentile for Charters Towers and the highest in 2007 was 591 mm.

The seven year average annual rainfall at the site was 455 mm. The first four years of the study, 2001-2004, were below this average with 420 mm or less per annum. In contrast the last three years, 2005-2007, received greater than 540 mm per year and are herein referred to as ‘wet years’.

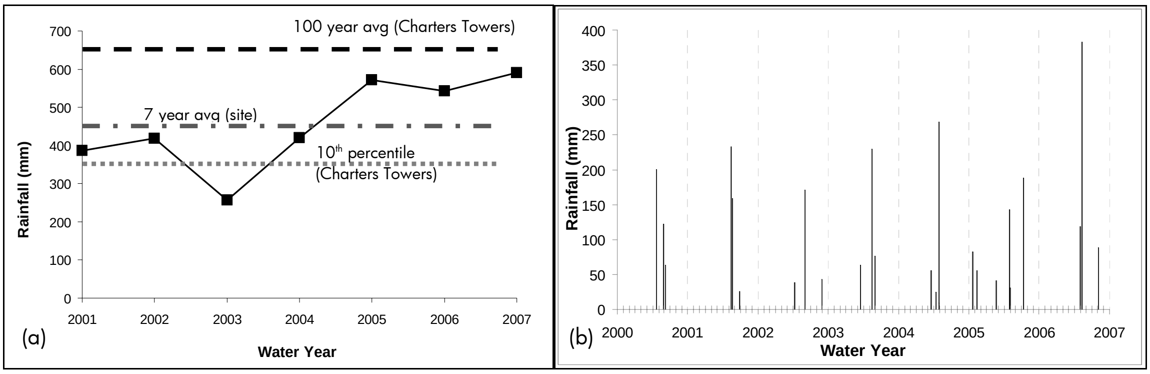

Figure 1 (a) Annual rainfall for the seven years of monitoring (b) Event rainfall distribution.

Runoff was generated from 25 rainfall events over the seven year study period ranging in size from under 10 mm up to 383 mm. Six of the 25 runoff events occurred prior to treatment. The mean rainfall event size was 117 mm (±18 mm). Three quarters of these events occurred from December to March. The two largest rainfall events occurred on 24 Jan 2005 at 268.8 mm and 7 Feb 2007 at 383 mm.

Total Discharge

The control hillslope generated three times the amount of runoff as treated hillslope both prior to and after treatment (Figure 2a). The total discharge after seven years was 396 mm and 122 mm for the control and treated hillslopes respectively. For the 5 years following treatment the totals were 339 mm for the control hillslope and 102 mm for the treated hillslope. The mean annual discharge was 68 mm

(±28 mm) for the control and 20 mm (±9 mm) for the treated hillslope. The differences between hillslopes are apparent during the two largest rainfall events (January 2005 and February 2007).

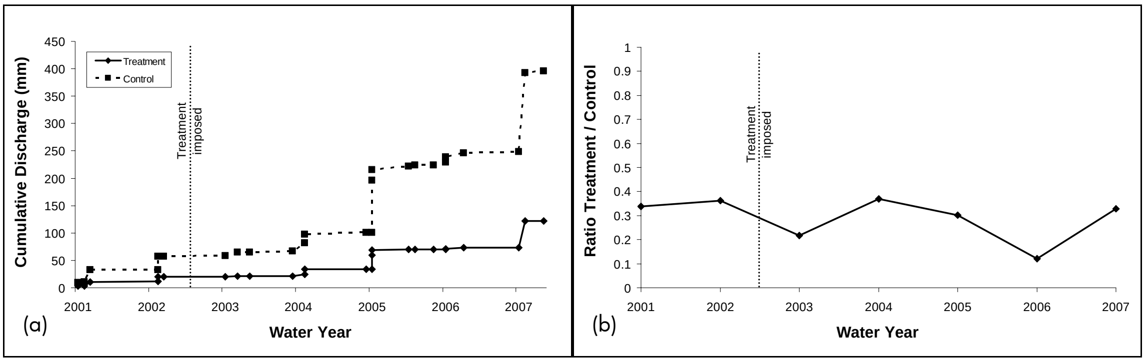

Figure 2 (a) Cumulative discharge per treatment for each runoff event between 2001 and 2007. (b) Ratio of annual discharge (mm) for treated versus control.

Ratio of Discharge

The ratio of discharge from treated to control is shown in Figure 2b. If the removal of grazing has an effect on discharge, we would expect this ratio to decrease after the 2002 water year. However, the ratio at the beginning of the experiment was 0.338 and 0.329 seven years later.

The lowest ratios occurred in 2006 after a previous wet year (0.12) and 2003, the first wet season after treatment (0.218). The rainfall for 2006 was more evenly distributed across the whole year with no single event greater than 200mm. The 2003 water year was also the driest of the study. There was little difference in the ratio of discharge for the 2005 or 2007 which had the highest quantity of discharge monitored (Figure 2a). Our data showed no relationship between the ratio of discharge and total rainfall at the event scale, annual scale, prior to treatment or post treatment.

These results show that there is no treatment response with respect to annual discharge although there may be a short term response to infrequent seasonal events as seen in 2003 and 2006.

Runoff Coefficient

The annual runoff coefficients for the treatment and control are shown in Figure 3. The greatest difference occurred during 2005 (the first wet year), although both treatments had high runoff coefficients. The runoff coefficients for the following two years remained below 10% even though annual rainfall was similar and the dominant rainfall event in 2007 was larger than that in 2005.

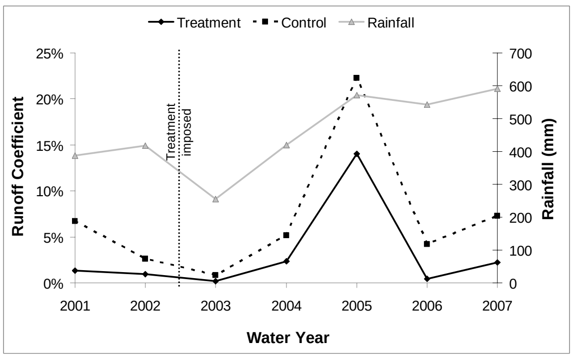

Figure 3 Annual runoff coefficients for treated and control hillslopes.

CONCLUSIONS

This study demonstrates that pasture management does not reduce hillslope runoff within 5 years, although changes can result after 15-20 years of stock exclusion. Improving surface condition may affect hillslope erosion rates and sediment mobilisation (not reported here); however, hillslope sediment transport capacity and downstream erosion will not respond to pasture management within 5 years. This means that the amount of runoff available to cause downstream gully and river bank erosion would not be affected within that time

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