Journal of Hydrology 389 (2010) 237–248

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Impacts of improved grazing land management on sediment yields, Part 1: Hillslope processes

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ARTICLE INFO

Article history:
Received 17 September 2009
Received in revised form 1 March 2010
Accepted 1 May 2010

This manuscript was handled by G. Syme, Editor-in-Chief

Keywords:
Great Barrier Reef
Soil erosion
Grazing
Runoff
Sediment

SUMMARY

Poor land condition resulting from unsustainable grazing practices can reduce enterprise profitability and increase water, sediment and associated nutrient runoff from properties and catchments. This paper presents the results of a 6 year field study that used a series of hillslope flume experiments to evaluate the impact of improved grazing land management (GLM) on hillslope runoff and sediment yields. The study was carried out on a commercial grazing property in a catchment draining to the Burdekin River in northern Australia. During this study average ground cover on hillslopes increased from ~35% to ~75%, although average biomass and litter levels are still relatively low for this landscape type (~60 increasing to 1100 kg of dry matter per hectare). Pasture recovery was greatest on the upper and middle parts of hillslopes. Areas that did not respond to the improved grazing management had <10% cover and were on the lower slopes associated with the location of sodic soil and the initiation of gullies. Comparison of ground cover changes and soil conditions with adjacent properties suggest that grazing management, and not just improved rainfall conditions, were responsible for the improvements in ground cover in this study. The ground cover improvements resulted in progressively lower runoff coefficients for the first event in each wet season, however, runoff coefficients were not reduced at the annual time scale. The hillslope annual sediment yields declined by ~70% on two out of three hillslopes, although where bare patches (with <10% cover) were connected to gullies and streams, annual sediment yields increased in response to higher rainfall in latter years of the study. It appears that bare patches are the primary source areas for both runoff and erosion on these hillslopes. Achieving further reductions in runoff and erosion in these landscapes may require management practices that improve ground cover and biomass in bare areas, particularly when they are located adjacent to concentrated drainage lines.

1. Introduction

Livestock grazing is Australia's largest land use occupying 58% of the continent (www.brs.gov.au/landuse). In many grazing areas poor land condition, resulting from unsustainable grazing practices, has reduced the productivity of land for beef production and increased water, sediment and nutrient yields leaving the landscape (e.g. Bartley et al., 2007; McKeon et al., 2004). Evidence suggests that excess sediments and nutrients can also impact on the water quality and ecology of adjacent rivers and streams (e.g. McIver and McInnis, 2007; Vidon et al., 2008) and downstream ecosystems such as the Great Barrier Reef (GBR) (Fabricius, 2005; Fabricius et al., 2005; McCulloch et al., 2003).

Sediments are delivered to streams from three main sources (hillslope, gully or bank erosion). Hillslope erosion is the source that has received the most attention in the last decade in rangeland regions of northern Australia (e.g. Bartley et al., 2006; McIvor et al., 1995; Scanlan et al., 1996), and internationally it is also well researched (e.g. Branson et al., 1972; Stone et al., 2008). Trimble and Mendel (1995) provide a thorough review on the range of impacts that grazing and cattle can have on catchment processes including soil hydrology, hillslope runoff, bank erosion and stream channel structure. Whilst previous studies have described the degradation process, few have looked at land condition recovery and subsequent water quality changes following cattle exclusion or reduction. For the few international studies that describe the changes (or improvements) to water quality following cattle removal from pastures and/or riparian areas, the rates of this change vary considerably from 2.5 to 10 years for phosphorus and sediment loads (e.g. Bishop et al., 2005; Ellison et al., 2009; Line

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doi:10.1016/j.jhydrol.2010.05.002

et al., 2000) to between 3 and 13 years for hillslope hydrology (e.g. Branson et al., 1981; Sartz and Tolsted, 1974).

In Australia, previous studies have evaluated whether changes to land management affect ground cover and land condition, particularly in a historical context (e.g. Ash et al., 2001; Bastin et al., 2001; McKeon et al., 2004), and a recent study found that sediment yields from hillslope plots were reduced by 50% after one year of cattle exclusion (Hawdon et al., 2008). Most of these studies were undertaken under controlled conditions involving exclosures or complete cattle removal (McIvor et al., 1995; Scanlan et al., 1996), and there are no known studies that have been carried out under commercial grazing conditions. Given the importance of grazing to the Queensland and Australian economies (Gordon, 2007), there is a need to understand how improved grazing management, rather than livestock exclusion, can improve land condition and potentially improve downstream water quality.

The primary focus of grazing land management (GLM) in rangelands is vegetation management (Ash et al., 2001). There are four principal ways to rehabilitate or prompt recovery in rangeland vegetation: (i) reduce livestock density or utilisation (with or without seasonal pasture resting), (ii) prescribed burning, (iii) sowing introduced plant species and (iv) reseeding native plant species (Noble et al., 1984). Utilisation is defined as the proportion of pasture growth consumed over a year (Ash et al., 2001). These methods are considered in the context of livestock production and may not necessarily be suitable for ecological management and restoration of vegetation communities.

In December of 2002, GLM strategies in the form of reduced utilisation and rotational wet season resting were implemented on Virginia Park cattle Station, in the Burdekin River catchment on Australia's east coast. This paper demonstrates how these improved grazing management strategies changed ground cover condition and associated water and sediment loss at the hillslope scale (~2030–12,000 m^2) over a 6 year period. The effect of this improved management on water and sediment yields at the catchment or property scale (14 km^2) is presented in (Bartley et al., 2010).

2. Study area

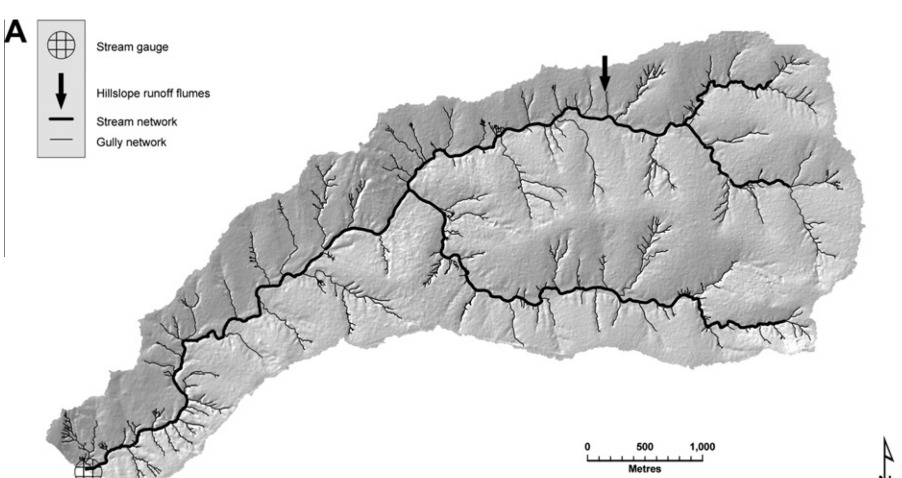
This study was carried out in the Weany Creek catchment (S19°53′06.79″, E146°32′06.65″), which is dominated by Eucalypt savanna woodland. The catchment is contained within Virginia Park station which is a privately owned cattle grazing property. The area is representative of the highly erodible 'gold-fields' (granodiorite) country between Townsville and Charters Towers in North Queensland, Australia, and has been grazed for more than 100 years. Weany Creek is an ephemeral 14 km^2 catchment of the larger Burdekin catchment (~130,000 km^2; Fig. 1). The Weany Creek catchment was chosen for this study due to its location in an area identified as having high erosion rates (Prosser et al., 2001), and due to the willingness of the landholders to trial sustainable grazing practices.

The soils in the catchment are generally Red Chromosols on the upper slopes and Yellow to Brown texture contrast soils with dispersive, natric B-horizons on the lower footslopes. Large bare scald patches are present on the slopes adjacent to many gully and stream networks. Scalds have formed on unstable duplex soils where the clay fraction of the sub-soil is high in sodium (Pressland et al., 1988). Long term overstocking on these soils has denuded the pasture, removed the A-horizon, and exposed the dispersible sub-soils along most of the drainage lines in this catchment.

The canopy vegetation is composed primarily ironbark/bloodwood communities (e.g. narrow-leafed ironbark, *Eucalyptus crebra* and red bloodwood, *Corymbia erythrophloia*) which are located primarily on the mid and upper slopes. The lower slope sodic soil communities are dominated by more shrubby species (e.g. currant bush, *Carissa ovata* and false sandalwood, *Eremophila mitchellii*). The ground cover is dominated by the exotic, but naturalised stoloniferous grass Indian Couch (*Bothriochloa pertusa*). Native tussock grasses such as Desert Blue grass (*Bothriochloa ewartiana*), Black Spear grass (*Heteropogon contortus*) and Golden Beard grass (*Chrysopogon fallax*) are present. Surveys of pasture composition over the study period show that native tussock grasses represent between 5% and 30% of total biomass depending on the paddock and year.

A map of the Virginia Park property and the location of the four study paddocks located within the Weany Creek catchment are shown in Fig. 2. It is important to point out that this grazing trial was initiated during a drought, on a property with generally low ground cover that was dominated by Indian Couch (>85% of total biomass). The ground cover and pasture biomass levels at the beginning of this project were on average ~63% and ~350 kg of dry matter per hectare (DM/ha), respectively. These values were well below what is considered 'sustainable' in terms of long term grazing management for this soil type (Ash et al., 2001).

There was a steady increase in the annual rainfall totals at Virginia Park between 2003 and 2007. With the exception of the 2006 and 2007 wet seasons all years were under the long term average (1901–2006) for nearby Fanning River rain gauge of ~584 mm



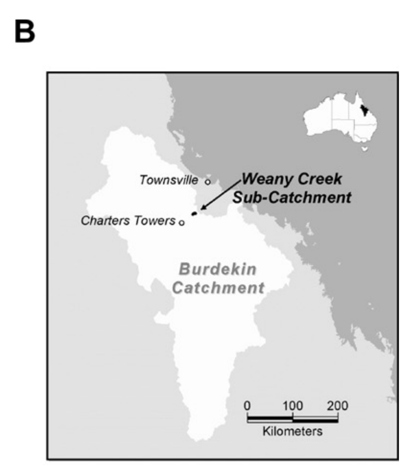


Fig. 1. (A) The Weany Creek catchment showing the stream and gully network and the location of field monitoring sites. The catchment outlet is in the southwest corner. (B) The location of the study catchment within the Burdekin River catchment.