Time-controlled grazing and soil erosion control under a catchment scale experiment in South-east Queensland, Australia

Gholamreza Sanjari[A,B], Bofu Yu[C], Hossein Ghadiri[A], Cyril A. A. Ciesiolka[D] and Calvin W. Rose[A]

[A]Griffith School of Environment; Australian River Institute, Griffith University, Nathan, QLD, Australia
[B]Research Institute of Forests and Rangelands, Tehran, Iran, Email g.sanjari@gmail.com
[C]School of Engineering, Griffith University, Nathan, QLD, Australia
[D]Department of Natural Resources and Mines, Toowoomba, QLD, Australia

Abstract

Grazing systems affect pasture production and hence surface cover which is the protective layer of soil against water erosion. Time-controlled (TC) grazing as an alternative to conventional grazing systems has become popular in some parts of Australia and rest of the world for its relatively higher pasture productivity. It involves short periods of intensive grazing which is of concern for environmental impacts and sustainability. To address some aspects of the issue, a runoff catchment experiment was established to investigate the effect of the newly adopted grazing system (TC grazing) on runoff and sediment loss from 2001 to 2006. The results show that sediment loss was reduced significantly over the study period as the surface cover increased. The reduction in soil erosion was achieved despite the fact that the increase in ground cover under TC grazing had little effect on runoff. Decrease in runoff and soil loss is mostly attributed to the higher level of surface cover (90%) achieved during the second period of the study (2004-2006) compared with 65% for the first (2001-2003). Long rest periods in TC grazing was seen to be the major contributor to soil and pasture recovery after the intensive defoliations and subsequent increase in above ground organic material providing soil erosion control.

Key Words

Runoff, soil loss, ground cover, pasture, Time-controlled grazing, Queensland, Traprock.

Introduction

Traditional practices including continuous grazing in rangelands usually lead to soil compaction with associated loss of pore structure and connectivity which reduce infiltration capacity (Greenwood and McKenzie 2001). For this reason under continual utilization of pasture species by grazing animals, as the stocking rate increases, runoff and soil loss increase (Rauzi and Hanson 1966). Introduction of rotational grazing system in the 1960s, that includes some periods of grazing exclusion, resulted in some improvement in soil and surface hydrology, through the increase in above and below ground organic materials. In south-east Queensland, time-controlled (TC) grazing, as a variant of rotational grazing is the main alternative to traditional grazing practices. This paper briefly provides information on the effects of TC grazing on runoff and soil loss based on the data collected from a small catchment practiced by TC grazing for 6 years.

Methods and materials

Study area

The research was conducted at "Currajong", a grazing property in the semi-arid region of south-east Queensland, Australia (28º 33' S, 151º 33' E, altitude 675 m). The area, known locally as Traprock, is located in the catchment of the MacIntyre Brook at the northern headwaters of the Murray Darling basin. The annual rainfall for the study area is 645 mm, with summer dominant of around 70% characterized by relatively high frequency of medium to large events of short (thunderstorms), and long (cyclonic depressions) durations. In the dry season (April to September), there are smaller events, both in magnitude and intensity associated with frontal depressions.

The soil is shallow to moderately deep with a hard setting brown to dark clay loam underlined by a bleached A2 horizon. Vegetation is open Eucalypt woodland with an understorey of native and naturalized perennial grass species dominated by a desirable species known as Queensland blue grass [*Dichanthium sericem* (R. Br.) A. Camus].

Treatments

The runoff catchment with area of 8 hectares; 8% slope and 40 cm average soil depth was instrumented by a San Dimas flume, automatic water sampler, two pluviometers and associated loggers. The height of the runoff flowing through the flumes was recorded in mm using a Greenspan pressure transducer positioned in

1 – 6 August 2010, Brisbane, Australia. Published on DVD.

the stilling wells. The surface runoff, passing through the flume, was sampled using automatic pumping samplers capable of holding up to 50 water bottles. A bilge pump, submerged in a mixing pond at the outlet of the flumes, was triggered to facilitate this action. The catchment was located in a research paddock with a long history of continuous grazing but converted to TC grazing from 2001 onward. The paddock including the runoff catchment was grazed with high stocking rates of 12.6 ± 6 DSE (Dry Sheep Equivalent)/ha in differing short durations (14 ± 9 days) and long rest periods (101 ± 60 days) depending on feed availability and rate of grass growth.

Results

The results showed a number of 27 runoff events were recorded in the catchment from 2001 to 2006. Total rainfall generating runoff was 1383 mm with overall runoff coefficient of 19.5% and the sediment loss of 439 kg/ha. The mass curves of runoff and soil loss using all runoff events (Figure 1a) illustrate decreasing trends in runoff depth and sediment loss with time despite the linear increase in rainfall. Regression analysis (Table 1) verified such decreasing trends in runoff and sediment which were best described by negative second order polynomial equations ($p< 0.01$). These results indicate a lower proportion of rain being converted to runoff towards the end of the study period and sediment loss reduced at a greater rate than runoff depth.

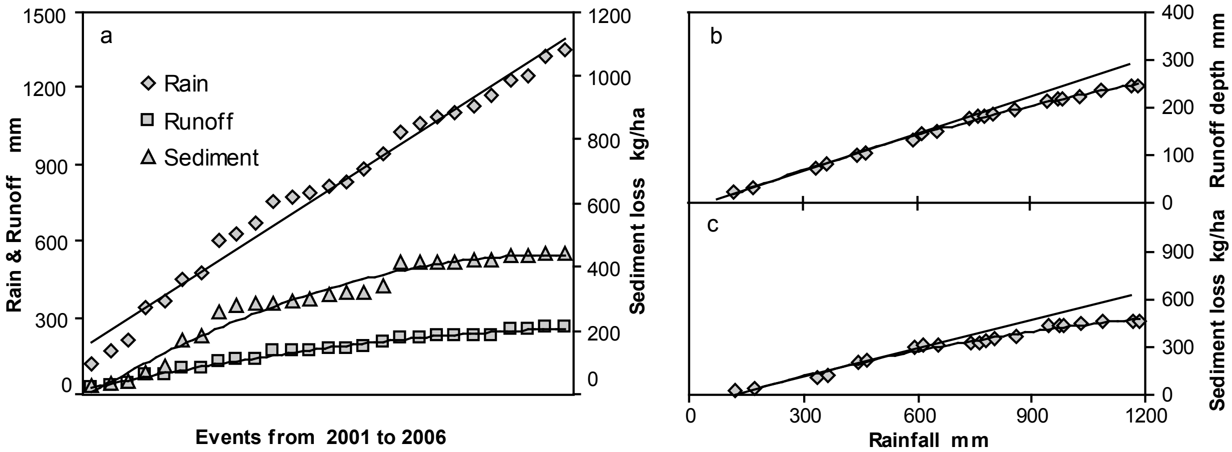

Figure 1. Mass curves of rainfall, runoff and sediment with time (a); double mass curves of rainfall-runoff (b) and rainfall-sediment loss (c) from 2001 to 2006

Under a selection of 21 runoff events, double mass curves of rainfall-runoff (Figure 1b) and rainfall-sediment (Figure 1c) also present the decreasing trends of runoff and soil loss through time ($p< 0.01$). It's again indicated a lower rate of rainfall converted to runoff with the same situation for sediment loss, being more noticeable over the second half of the study period. The results of the polynomial regression analysis (Motulsky and Christopoulos, 2004) employed in this study (Table 1) verified such significant declining trends of runoff and sediment through time under TC grazing. This analysis determines the extent to which the newly added second order term in the curvilinear model significantly increased R^2 or decreased SSE of the residuals.

Table 1. Polynomial regression analysis for runoff and soil loss.

Curve's name	Equations of best fit	R^2	df	F
Mass curves of rainfall depth with time	$Y= 45.46X + 160.14$	0.98		
Mass curves of runoff depth with time	$Y= – 0.233X^2 + 15.48X + 9.64$	0.99	2:24	96***
Mass curves of sediment loss with time	$Y= – 0.646X^2 + 34.7X – 29.41$	0.97	2:24	56***
Double mass curves of rainfall-runoff	$Y= – 0.0007X^2 + 0.3X – 17.5$	0.99	2:18	108***
Double mass curves of rainfall-sediment	$Y= – 0.0002X^2 + 0.71X – 80.4$	0.98	2:18	21.5***

*** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$

The decline in runoff and soil loss is pronounced over the latter years of the study where the grass cover reached and sustained its highest level. The records of ground cover corresponding to the time of the runoff events (Figure 2a) show two distinct periods of low and high surface cover achieved under TC grazing during the course of the study. It suggests a mean ground cover of 65% for the first period of the study (2001-2003) and 90% for the second (2004-2006) which is higher than the minimum safe threshold of 70% recommended for the region (Sanjari *et al.* 2009). The gross values on runoff and sediment over the two periods of the study (Figure 2b) illustrate a significant decrease in sediment loss and to some extend in runoff from the first period to the second, despite 5% increase in total rain and 1% increase in rainfall erosivity (6962 to 7048 MJ/ha*mm/hr) in the second period.

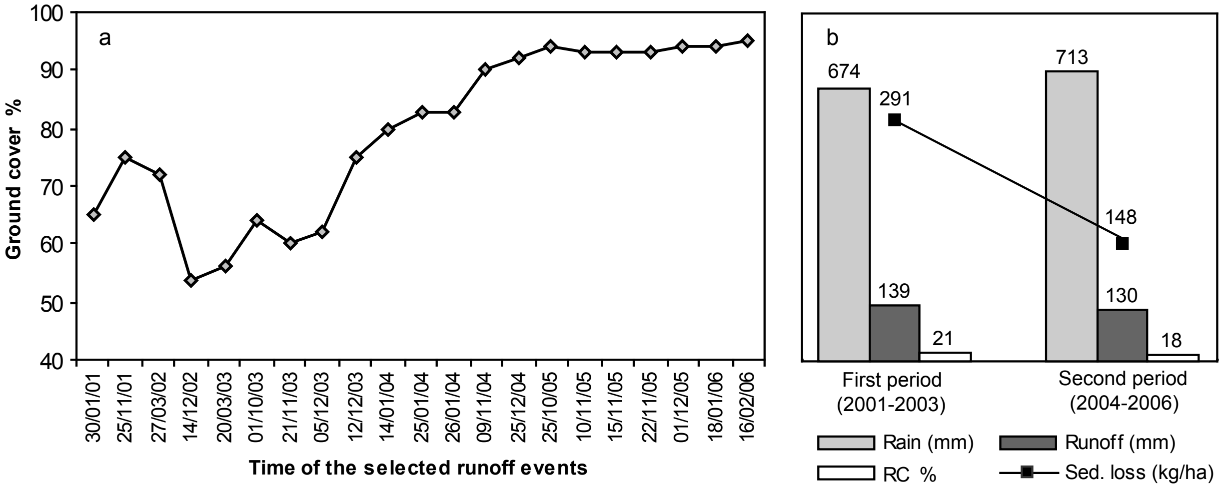

Figure 2. Ground cover changes over the study period (a); total rainfall, runoff, runoff coefficient (RC) and sediment loss over the first (2001-2003) and second (2004-2006) periods (b).

A decrease in runoff and soil loss could be a result of an increase in infiltration and interception facilitated by the higher level of both ground and foliar covers which protect the soil surface against raindrop impact and surface runoff (entrainment and re-entrainment). An increase in soil organic matter and ground litter in this area reported earlier by the authors (Sanjari *et al.* 2008) are also the factors that may have increased infiltration and reduced runoff and soil loss.

Inclusion of long rest periods in TC grazing is an important factor for soil and pasture recovery. In the study area, there are high chances of having some consecutive favorable wet conditions over the rest periods, entering the main inputs into the process of pasture recovery which triggers a mass regrowth. For instance, over the growth season of 2003-2004, the catchment was rested for 156 days, during which a total of 480 mm rainfall occurred. Such a coincidence produced large amounts of organic matter that has been a major resource for ground cover.

Some studies under rotational grazing (McGinty *et al.* 1979; Wood and Blackburn 1981) have emphasized on the significant effect of rest duration on runoff and soil loss compared with continuous grazing and even non-grazed areas. In Texas, USA, Warren *et al.* (1986a) found some soil recovery during a 30 days rest period. This was evident from the higher infiltration rates and lower sediment loss recorded at the end of the rest periods compared with the beginning of them.

Conclusion

The grazing system of Time-controlled, showed that under prevailing conditions of the study area, has potential to increase ground cover from 65% in the first period of the study (2001-2003) to 90% during the second, only three years after conversion from continuous grazing. This amount of surface cover provided the soil surface with adequate protection, resulted in significant decrease in soil loss over the second period of the study. This capability is attributed to the provision of sufficient rest periods, allowing a great accumulation of above and below-ground organic matter and surface residue. Runoff also decreased over the second period but not as much as sediment did. Time-controlled grazing appears to be efficient in reducing runoff over a longer period of time with a favorable soil and climatic conditions, where a larger increase in soil organic material is expected to occur.

References

Greenwood KL, McKenzie BM (2001) Grazing effects on soil physical properties and the consequences for pastures: a review. *Australian Journal of Experimental Agriculture* **41**, 1231-1250.

McGinty WA, Smeins FE, Merrill LB (1979) Influence of soil, vegetation, and grazing management on infiltration rate and sediment production of Edwards Plateau rangeland. *Journal of Range Management*

32, 33-37.

Motulsky H, Christopoulos A (2004) 'Fitting Models to Biological Data using Linear and Nonlinear Regression.' (Oxford University Press: USA).

Rauzi F, Hanson DL (1966) Water intake and runoff as affected by intensity of grazing. *Journal of Range Management* **19**, 351-356.

Sanjari G, Ghadiri H, Ciesiolka CAA, Yu B (2008) Comparing the effects of continuous and time-controlled grazing systems on soil characteristics in Southeast Queensland. *Australian Journal of Soil Research* **46**, 348-358.

Sanjari G, Yu B, Ghadiri H, Ciesiolka CAA, Rose CW (2009) Effects of Time-Controlled Grazing on Runoff and Sediment Loss *Australian Journal of Soil Research* **47**, 796-808.

Warren SD, Nevill MB, Blackburn WH, Garza NE (1986a) Soil Response to Trampling under Intensive Rotation Grazing. *Soil Science Society of America Journal* **50**, 1336-1341.

Wood MK, Blackburn WH (1981) Grazing Systems: Their Influence on Infiltration Rates in the Rolling Plains of Texas. *Journal of Range Management* **34**, 331-335.