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BIOPHYSICAL AND HYDROLOGICAL CHANGES IN SOILS UNDER LIVESTOCK GRAZING VARYING SLOPES IN THE EAST AFRICAN HIGHLANDS

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ABSTRACT

The impacts of grazing on biophysical and hydrological properties of grazing lands were investigated on two sites representing 0-4 % and 4-8 % slopes at the Livestock Research Institute (ILRI) Debre Zeit research station, 50 km South of Addis Ababa. Grazing pressure differently influence ground vegetative cover, increased surface runoff and soil loss, and reduced water infiltrability of the soil between the two land slopes. Grazing management strategies need to be 'slope-specific' and more research is needed to quantify biophysical changes in order to assess cumulative long term effects of grazing and trampling on vegetation, soil, and hydrology of grazing lands and complement efforts that seek to cohesively and compatibly manage land resources to sustainably serve multiple needs of communities.

KEYWORDS

Grazing, trampling, vegetative cover, infiltration, runoff, erosion, highlands

INTRODUCTION

Trampling while grazing can remove protective plant cover and damage soil, particularly by modifying soil physical and hydraulic properties (Mwendera & Mohamed Saleem, 1996). With the reduction in vegetative cover, especially at heavy stocking rates, water infiltration rates decrease, and surface runoff and soil erosion increase. Systematic study of bio-physical and hydrological changes are therefore needed to quantify short- and long-term grassland responses to livestock grazing in different land slopes for developing a cohesive plan with cropping and other potential land uses.

MATERIALS AND METHODS

The study was conducted at two sites; site 1 (0-4 % slope) and site 2 (4-8 % slope) on an Alfisol located at the ILRI Debre Zeit Research Station in the Ethiopian highlands (1850 m asl), 50 km south of Addis Ababa (8½44'N; 38½58'E). The area receives mean annual bimodal rainfall of 650 mm, 30 % of which fall during the short rainy season between March and April, and a long rainy season between June and mid September.

The six treatments which were imposed on natural pasture were 'light grazing' stocked 0.6 animal-unit-month per hectare (AUM/ha); 'moderate grazing' stocked at 1.8 AUM/ha; 'heavy grazing' stocked at 3.0 AUM/ha; 'very heavy grazing' stocked at 4.2 AUM/ha; very heavy grazing on ploughed soil, simply referred to as 'ploughed', stocked at 4.2 AUM/ha; and a control with 'no grazing'. Vegetation cover and biomass yields were determined. Sediment and water samples were collected after each rainfall runoff-event and suspended material was determined using the filtration method and fixed-volume method (Barnett and Holladay, 1965). Ponded infiltration rate was measured using double-ring infiltrometer at the beginning of the dry season.

RESULTS AND DISCUSSION

All levels of grazing intensity reduced the amount of vegetative cover at both sites (Table 1). On the 0-4 % slope, the difference in ground cover was not statistically significant between the different treatments except the very heavily grazed ploughed plots, although percentage cover tended to be greater when plots were lightly and moderately grazed than heavily to very heavily grazed. On the 4-8 % slope, the ground cover under heavy to very heavy grazing was less than under light to moderate grazing ($P<0.05$).

As grazing pressure increased surface runoff increased compared to the control (Fig. 1), and runoff from heavily to very heavily grazed plots was significantly greater than from light to moderately grazed plots. Runoff from plots with 0-4% slope was consistently less across all levels of grazing intensity than from plots with 4-8% slope. The rates of soil loss were consistently greater from heavily grazed plots than from lightly grazed plots (Table 1). Taking the average soil loss in a storm event in natural pastures in Southern Ethiopia of 0.03 t/ha (Belay Tegene, 1992) as a "safe limit", it was observed that 75 % ground cover was a critical limit on plots with 0-4% slope while 85 % ground cover was critical limit on plots with 4-8% slope, which suggests that efforts to increase biomass productivity should be primarily to maintain the level of ground cover and to support the livestock population. As grazing intensity increased, livestock trampling significantly reduced infiltration rates and the reduction in infiltration rates was significantly more on plots with 0-4 % slope than the 4-8 % slope. This was probably due to the fact that land with 0-4 % slope had fine textured topsoil which contained higher clay and silt particles.

CONCLUSION

Grazing pressure and compaction due to trampling are likely to affect vegetative cover, runoff and soil loss differently on land with varying slopes. Gentle slopes may be subjected to greater grazing pressure without seriously risking a possible decrease in biomass compared to steeper slopes. Therefore, greater efforts are required to maintain "critical" levels of ground cover to minimize soil loss on steeper than gentle slopes. This, however, is yet to become a serious consideration in traditional grazing practices. Steep slopes are rapidly encroached by cultivation as productivity on moderate slopes decline and land pressure for growing food crops increase. Livestock are pushed to steeper slopes, and during the crop growing season the entire ruminant populations are spatially confined there, raising the risk of wide scale land degradation. In the east African highlands, such unsustainable practices have become major environmental threats and cause for human suffering. Natural integrity of the steep lands need to be preserved by maintaining vegetative (pasture) soil protective cover. This is possible only if productivity of gentler slopes and better agricultural lands can be more intensively and profitably used. While increasing productivity, food security and environmental safety are being pursued with greater encouragement for farmer participation, new opportunities are emerging to manage grazing resources as well. The livestock and floral diversity that need to be encouraged for environmental safety and to provide for multiple human needs are some of the issues being addressed by ILRI and its research partners. This study demonstrates that there is a need for more systematic assessment of grazing in relation to land response in the highland areas.

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Table 1
Vegetative ground cover (%), steady state infiltration rate (mm/hr), and cumulative soil loss (t/ha) from July to August, 1995, at site 1 (0-4 % slope) and 2 (4-8 % slope).

Grazing treatment	Vegetation cover		Infiltration rate		Soil loss	
	Site 1 slope	Site 2 slope	Site 1 slope	Site 2 slope	Site 1 slope	Site 2 slope
No grazing	100a*	100a	17.6a	13.4a	0.2a	0.5a
Light grazing	98a	99a	11.6a	6.8b	0.6a	0.7a
Moderate grazing	97a	93ab	10.9a	8.6b	0.3a	1.4b
Heavy grazing	95a	90b	7.6ab	7.2b	1.0b	1.5b
Very heavy grazing	91a	81c	5.3bc	6.8bc	0.7a	1.8b
Ploughed	56b	52d	2.4c	6.1c	1.6c	1.8b

* Means with the same letter in a column are not different (P<0.05) from Duncan's Multiple Range Test.

Figure 1
Accumulated surface runoff from plots at the two sites from July to August, 1995.