



Influence of topographic and edaphic factors on vulnerability to soil degradation due to cattle grazing in humid tropical mountains in northern Honduras

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ABSTRACT

Low altitude humid tropical mountains in Central America have experienced a process of livestock expansion during recent decades. However, the use of sloping areas for cattle grazing may lead to significant soil degradation and therefore we examined the influence of the slope gradient on soil degradation in pastures in a humid tropical mountainous area in northern Honduras. Understanding this relationship permits estimates of the physical carrying capacity of the soil, which in turn may help to improve livestock use within the study area. Variables examined included soil bulk density, texture, organic matter content and consistency as well as visual indicators of soil and vegetation degradation. There is a significant positive correlation between the bulk density as a proxy for soil degradation and slope gradient. Furthermore, it was found that when soils are water-saturated grazing leads to severe degradation. Together with visual indicators, these data show that paddocks with slopes less than 30% have a carrying capacity between 900 and 1900 Animal Units (AU) ha⁻¹ year⁻¹ and many are currently underutilized. Paddocks with slopes between 30 and 50% have a carrying capacity between 400 and 600 AU ha⁻¹ year⁻¹. Paddocks with slopes over 50% have the lowest carrying capacity: less than 200 AU ha⁻¹ year⁻¹. The latter are frequently over-used; most of them show clear signs of soil and vegetation degradation. Land use in these areas needs to change or their grazing management needs to be reorganized to adjust actual stocking rate to physical carrying capacity of the soils to prevent further degradation.

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1. Introduction

Worldwide, livestock production has increased significantly during the past decades and is expected to continue to grow in coming years (FAO, 2006). However, due to the increasing concern about the negative effects of livestock production on the environment, the FAO (2009) recently stressed that this impact needs to be mitigated. Specifically, soil, vegetation and water degradation needs to be addressed (Steinfeld et al., 2006).

Processes that lead to soil degradation by grazing cattle are reasonably well understood, especially in temperate climates (Greenwood and McKenzie, 2001; Bilotta et al., 2007; Drewry et al., 2008). Grazing often results in soil compaction due to the weight of the animals and the mechanical forces that cattle apply when walking on the soil (Willat and Pullar, 1983; Steffens et al., 2008). Soil compaction may have negative consequences such as reduced rainfall infiltration, enhanced soil erosion (Bari et al., 1995; Russell et al., 2001) and degradation of the herbaceous vegetation cover (Bouman et al., 1999; Alados et al., 2004). The vulnerability of a soil to degradation by compaction is related to soil management, certain soil properties and environmental variables, as

well as interactions between them (Blackburn, 1984; Blanco, 2008). For instance, Van Haveren (1983) stressed the importance of soil texture in his study in Colorado (USA), while Wind and Schothorst (1964), under controlled (laboratory) conditions, found a strong relationship between soil compaction and soil humidity as well as with organic matter content. Johnston (1962) reported that the variables that most strongly influenced soil compaction in Alberta, Canada, were vegetation type and vegetation cover. Blanco (2004a, 2008), studying mountainous areas in southern Spain, found that the factors with greatest influence on soil compaction caused by grazing were the calcium carbonate content of the soil, the vegetation cover and topography, specifically the exposure of the slope (north–south). The latter was also found by Golodets and Boeken (2006) in their study in the Negev (Israel).

However, such studies under tropical conditions are scarce, as are studies on the relationship between soil compaction, soil degradation caused by grazing cattle and slope gradient. Furthermore, very few studies (e.g., Blanco, 2004a, 2008) attempt to estimate the physical carrying capacity of soils for cattle grazing. Carrying capacity needs to be determined for effective land use planning for livestock production at different levels as well as for planning concrete actions that mitigate the impact of livestock grazing on natural resources.

As in other areas of Latin America, in the three Central American countries of Nicaragua, Honduras and Guatemala, available data indicate that the area dedicated to pastures increased from 2.4 to 5.6 million

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hectares between 1950 and 1991 (Szott et al., 2000), and most likely increased even more in subsequent years. During the same period, the herd size increased from 3.0 to 6.5 million animals. Many of the pastures were established in mountainous areas after deforestation (Kaimowitz, 1996). The loss of the tropical forest cover and its substitution with crops or pastures has important consequences for the physical, chemical and biological properties of the soils (Aide and Cavelier, 1994; Fernandez et al., 1997; Krishnaswamy and Richter, 2002) and may considerably enhance the vulnerability of the soil to degradation processes. The objective of our study was to analyze the influence of slope gradient on soil vulnerability to degradation in a humid tropical mountainous region (Caribbean slopes of Honduras), in order to estimate the carrying capacity for cattle grazing.

2. Materials and methods

2.1. Site characteristics

Two livestock farms were studied, located in the humid tropical mountains of the North of Honduras, in the municipality of Olanchito, Department of Yoro (Fig. 1). The mean annual rainfall in the town of Olanchito is 2042 mm, with a high inter-annual variability, (1600 to 2500 mm year⁻¹). Mean monthly rainfall varies between 40 and 100 mm during February–May, which is considered the “dry season”, and between 130 and 260 mm during the rest of the year, considered the rainy season. Although no measured data are available, owners estimated that both studied farms receive more rainfall than the town of Olanchito. The mean average annual air temperature is 23.7 °C.

The first farm, called “La Alameda”, is located at 15°32′N, 86°24′W, at altitudes between 300 and 550 m above sea level. The farm has an extension of 77 ha and an average slope gradient of 55%, although in some sites slopes are more than 90% (Table 1). The second farm, called “Quisa”, is located at 15°32′N, 86°22′W, at altitudes between 160 and 260 m, covering 92 ha; paddocks have an average slope gradient of 40% (Table 1).

After deforestation of the Quisa farm in the late 19th century, the land was used mainly for basic grain cultivation. Livestock became

Table 1
Area of the study farms under different ranges of slope gradients.

Slope gradient		La Alameda farm		Quisa farm	
%	Degree	ha	%	ha	%
0–10	0–5	1.7	2.2	3.1	3.3
10–20	5–11	0.4	0.5	1.2	1.4
20–30	11–16	2.3	3.0	7.2	7.8
30–50	16–26	24.7	32.0	32.8	35.7
50–70	26–35	41.3	53.5	46.9	51.1
>70	>35	6.8	8.8	0.6	0.7
Total		77.2	100	91.8	100

important during the first decades of the 20th century, and gradually replaced agricultural land use until all the land was used for livestock grazing. The forest that covered the La Alameda farm until the late 1970s was gradually replaced by crops and pastures. At present about 90% of this farm is under pasture. The dominant grass species in both farms is *Brachiaria decumbens*, while to a lesser extent also *Brachiaria brizantha*, *Panicum maximum*, and *Cynodon pleistotachus* are present.

At the time of this study cattle herds were 60 cows (in production) in the Alameda farm and 78 cows in the Quisa farm. Pasture rotation was commonly used, usually with one or two paddock shifts per day. Based on information from the farmers, that was verified in the field during three months, an accumulated stocking rate for the paddocks (Blanco, 2004b) was estimated using the annual number of hours the farm herd spent in each paddock. An accumulated stocking rate was used because Scholefield and Hall (1986) showed that one of the mechanisms that strongly influences soil compaction is the number of times that livestock treading occurs in the same place. This implies that it is necessary to take into account herd size and the duration of occupation of each paddock throughout the year in order to estimate stocking rate more precisely. A conversion rate of 1 Animal Unit (AU) = 400 kg live weight was used. Estimations indicated that the accumulated stocking rate was reasonably well distributed since 86% (La Alameda farm) and 79% (Quisa farm) of the area of the farms presented a stocking rate of less than 400 AU per hectare per year (Table 2). The rest of the areas had accumulated



Fig. 1. Location of the study area.

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