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Small ruminant impacts on rangelands of semiarid highlands of Mexico and the reconverting by grazing systems☆

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ABSTRACT

The north-central semiarid region of Mexico has been exposed to systematic grazing since colonial times. The grazing impact on rangelands has degraded soils and reduced diversity and productivity. The most common and detrimental cause of soil degradation is soil erosion which destroys chemical, physical and biological properties. To determine the effect of grazing systems on rangelands, several studies were performed. Such studies included a description of soil profiles to categorize degradation and the evaluation of water erosion changes due to further degradation processes under grazing systems (rotational, RG and continuous, CG). The study was carried out on a rangeland of the ejido Pánuco, Zacatecas, from 2002 to 2005. Soil degradation was classified by identifying 6 groups with similar soil profiles (GSSP) which were described as: (1) low degradation soil; (2) medium degradation soil with A horizon lost; (3) high degradation soil without A and B horizons lost; (4) high degradation soil with *in situ* development; (5) high degradation soil with calcareous material; and (6) high degradation soil without development, which is a very shallow soil above the parental material. Further degradation was determined by soil erosion measurements performed in the study area and the surroundings. With respect to soil losses their values were systematically less for the RG system under the native vegetation conditions studied ($P < 0.01$). Changes in the production systems may imply a reconversion of the system. Some changes include a modification in the intensity of use of rangelands, starting with a new grazing system, as well as changes in technology which may be simulated by GIS.

1. Introduction

The Mexican semiarid region has been exposed to systematic grazing since Spanish colonial times. Historical reports such as the Metalcingo Valley (Toluca, México) documents (Esparza, 1988), evidenced Spaniards' interest not only on mining, but also on livestock production, and recognized cattle production and overgrazing as a destabilizing force affecting crop (particularly corn) production, as early as the 16th century. Prompted by the consequences of cattle pressure on land productivity, in 1545 cattle was transferred to less populated areas in northern Mexico.

Due to their natural adaptation to harsh environments sheep and goats added progressively more to the livestock population of northern Mexico. By 1864, in Zacatecas alone there were 900,000 sheep and 500,000 goats. Livestock were raised extensively in vast range territories, i.e., by

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1889, Zacatecas rangelands represented the major feeding source, over 3,270,000 ha (Esparza, 1988). Cattle usually utilized the best range areas whereas sheep and goats grazed the most abrupt and harsh rangelands containing a fragile rain-dependent sparse and xerophitic vegetation.

An important tenure organization in the rural sector emerged in Mexico after the 1910 Mexican Revolution; i.e., the Ejido, a territorial unit that contains areas for communal and private use was allocated to a given number of families. Access to communal land was unrestricted to all members and exploited without any regulation so that as livestock species increased per family overgrazing took place with degradation consequences. Most livestock production systems are currently exploited under the Ejido tenure and nearly 50% of the ejidos involve range undergoing systematic degradation due to overgrazing. Furthermore, agricultural mono-cropping associated with inadequate cropping systems contributed as another degradation driver. In the state of Zacatecas, more than 77% of the total surface dedicated to agricultural and rangeland uses are under continuous degradation (Echavarría et al., 2009b), especially those under a communal regime.

Soil erosion is recognized as the most common and detrimental force causing soil degradation in arid and semiarid areas, particularly because its destructive effects on the chemical, physical and biological properties of the soil horizon (Whisenant, 1999). The continuous presence of a herd with a number of animals higher than the rangeland's carrying capacity systematically reduces the vegetation cover (Wood and Blackburn, 1984; Holechek et al., 1995) which makes the soil surface more susceptible to erosion by rain, wind, or a combination of these two (Wischmeier and Smith, 1978). The erosion, in turns, affects soil nutrient and humidity storage capacity (Rodriguez-Iturbe, 2000), leading to a further loss of vegetation, intensifying the degradation process (Whisenant, 1999). Several authors (Gifford and Hawkins, 1978; Wood et al., 1978; Blackburn, 1983) have shown the beneficial effects of rational use of rangelands in reducing soil erosion and promoting vegetation recovery and soil's water storage capacity enhancement by improving soil infiltration. In this context, different grazing strategies have been devised, i.e., rotational grazing, to not only reduce degradation but also promote a recovery of the soil's condition through alternating resting and use periods in different time and spatial arrangement (Holechek et al., 1995; Wood and Blackburn, 1984; Blackburn, 1983, 1984).

The adoption of appropriate management changes towards a rationalization of land use in communal land in the Ejido structure in Mexico, has been hampered. The absence of institutional and policy supporting measures for the proposed changes is not readily accepted and assumed by all the herd holders. These changes imply, reconverting the whole system, by shifting the actual productive activity to an activity of a lower extractive level (DOF, 2002), for instance from agriculture to livestock. The reconverting could also imply appropriate changes in the production system leading to an improved livelihood of farmers while achieving a sustainable use of the land; for instance, a modification in the intensity of range use such us the application of a new grazing system, coupled with the application of improved forage production, feeding and herd management practices that increase productivity, open possibilities for value addition and reduce overgrazing effects.

This paper describes studies conducted on communal land in an Ejido subjected to land degradation, to determine the effect of grazing systems on rangelands, as a means to offer reconverting alternatives for better management of communal rangelands in Mexico. The studies include a description of soil profiles to categorize former degradation and the assessment of soil water erosion due to contrasting grazing systems. A final discussion is offered in relation to range reconverting considering the effect of a grazing system.

2. Materials and methods

2.1. Study area

The study was carried out in the agrarian community of Ejido Pánuco, which is located in the municipality of Panuco, state of Zacatecas, Mexico (23°05′36″ to 22°50′40″ N and 102°19′54″ to 102°39′51″ W). Panuco's territory includes a 4914 ha. In Panuco, 2444 ha are dedicated to agriculture and 2470 ha to communal range grazing. The study site involved an exclusion area located in Panuco's rangeland surface (22°54′48″ N, 102°32′40″ W). Landscape in the area varies from steep slopes (2400 m asl in the southern area) to rolling planes (2125 m asl in the northwest part). Leptosols cover 91.5% of the rangelands and 36% of the agricultural area, whereas Calcisols cover 54% of the agricultural area and 8.5% of the rangelands. Kastanozem soils (WRB, 2006) affect only 4.4% of the land, mainly located in the northeast agricultural area (Echavarría et al., 2004).

The vegetation includes medium thorny bushes, predominantly wild cacti-thorny shrubs (COTECOCA, 1980). Grasses include *Bouteloua curtipendula* tenius Gould et al., *Bouteloua gracilis* (*HBK*) Lag, *Aristida* spp, *Lycurus phleoides* HBK, and wild cacti include *Opuntia leucotricha* D.C., *Opuntia streptocantha* Lem, *Opuntia rastrera* Weber, *Opuntia hyptiacantha* Weber, *Opuntia megacantha* Salm-Dick and *Opuntia pachona* Griffiths. The thorny bush vegetation is composed of bushes and annuals such as *Acacia farnesiana* (L) Willd, *Prosopis laevigata* (Willd) M.C. Johnston, *Mimosa biuncifera* Benth and *Dalea bicolor*.

2.2. Prevailing production systems

Of the three defined production systems prevailing in semiarid Mexico (Salinas, 1995), the state of Zacatecas is composed of two typical systems, one dedicated to kid goat production, located in the northern part of the state with limited rainfall; and the second involving a larger area that includes the municipality of Panuco, dedicated to meat production with access to stubbles and rangelands more suitable for grazing.

2.3. Former soil degradation

- Groups with same soil profile (GSSP): The creeks in the study area were used as observation pits to describe the soil profile. A representative area (53 ha) from the total 2470 ha in the communal land, dedicated to range grazing, was used to describe the soil degradation process. Seventy four soil profiles were described, most observed at the creeks and only a few described at agrologic wells, to identify how soil degradation evolves along different soil types. Description was done by following the Colegio de Postgraduados (1977) methodology. Soils were classified considering representative horizons located in the study area, and according to WRB (2006). Groups with the same soil profile (GSSP) degradation were built by connecting sites with similar features by means of interpolation using the kriging geostatistical techniques (Isaaks and Srivastava, 1989).
- Water potential erosion estimation: The GSSP were associated to topography and water erosion levels by means of the IDRISI program (Eastman, 1995). Water erosion was estimated from the universal soil loss equation (USLE) (Wischmeier and Smith, 1978):

$$E = RKLS \quad (1)$$