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Grazing effects upon plant community structure in subhumid grasslands of Argentina*

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Abstract

Changes in plant community structure are identified as a result of grazing in grasslands of the flooding pampa which evolved under supposedly light grazing conditions.

The effect of excluding grazing upon total leaf area index was an increase of 30%. The largest response was observed in the distribution of leaves in the canopy. In the grazed areas, most of the green material was concentrated in the 0–5 cm layer while in the ungrazed treatments the largest portion of the leaf area was in the 10–30 cm layer. Grazing exclusion resulted in a small change in total basal area but a larger change in its distribution, from many small tussocks to less numerous large ones.

The effect of grazing upon leaf area and basal area was accounted for by changes in vigor as well as by changes in species composition. The major effect of excluding grazing upon species composition was the disappearance of some native planophile species and most of the exotics. The species composition of grazed areas of both communities was very similar while there were large differences between the ungrazed areas and between the grazed and ungrazed areas of the same community. It is suggested that there is a group of species which responds to the coarse-grained 'signal' of grazing and its presence can cause dissimilar communities to converge under grazing conditions. The other group of species responded to the fine-grained 'signal' of the environmental conditions associated with topography.

Introduction

Plant community structure refers to the spatial configuration and species composition of a plant community. It may be characterized by description of the vertical and horizontal distribution of leaves, and a list of species or of groups of species. Most grassland utilization techniques modify plant community structure. Grazing by domestic herbivores can significantly influence species, life form and growth form composition of plants. Many rangeland improvement practices are directed at modifying plant community structure (Stoddart *et al.*, 1975).

The objective of this work was to identify and describe the major changes in plant community structure as a result of grazing by domestic herbivores in the grasslands of the flooding pampa, Argentina. Our interest was focused toward knowing the result of excluding large ungulates upon (a) species composition; (b) species diversity; (c) total leaf area; (d) horizontal and vertical distribution of leaf area and (e) total cover. Grasslands of the flooding pampa, which evolved under light grazing conditions (Webb, 1978), were disturbed after the arrival of Europeans in the 16th century with their domes-

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* Nomenclature follows Cabrera (1968).

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tic herbivores and probably the frequent use of fire. No relict grasslands are known in the flooding pampa.

The flooding pampa is a region in the Province of Buenos Aires, Argentina, of ca. 5 million ha which is covered in 80% of its area by native grasslands (León *et al.*, 1984). Annual mean precipitation is 924 mm and mean monthly temperatures range from 6.8 °C in July-August to 21.8 °C in January. Flat topography, along with low hydraulic conductivity in the B horizon, determine the occurrence of both flooding events and droughts (Sala *et al.*, 1981a). Despite these constraints and because of mild weather conditions, phenology and biomass dynamics did not show a well-defined growing season (Sala *et al.*, 1981b).

As a result of a phytosociological analysis of a 650000 ha strip along the major gradient of the flooding pampa, several plant communities were defined (León, 1975). Among them the most conspicuous were an upland community with *Piptochaetium montevidense, Ambrosia tenuifolia, Eclipta bellidiodes* and *Mentha pulegium*, and a lowland community with *Mentha pulegium, Leontodon nudicaulis* and *Paspalidium paludivagum.* These two plant communities are the major components of an intricate mosaic. The lowland community occupies areas which are topographically lower (15 – 20 cm) and therefore flooding periods are longer than in the extended flat areas occupied by the upland community.

Methods

To assess the effect of grazing on plant community structure two treatments were selected: no grazing by large ungulates and year-round grazing with a stocking rate of 1 head of cattle per hectare which is the typical management for the region. Exclosures of an area of 4 ha were installed 4 years before these measurements started. The vertical distribution of leaf area and basal area by species were evaluated during a year in the grazed areas and in the exclosures of both plant communities.

To assess total leaf area and its vertical distribution a technique similar to the one described by Joggi *et al.* (1982) was utilized. In each treatment, five samples were extracted which had ends of 20 × 10 cm and a height equal to that of the canopy. Samples were divided in 7 layers: 0 – 5, 5 – 10, 10 – 15, 15 – 20, 20 – 30, 30 – 40 and >40 cm. Green leaves, green stems and standing dead were separated for each layer. Area of green leaves was measured with an electronic meter.

Basal area was estimated by means of the line intercept method (Greig-Smith, 1964). Two 5 m lines were used in each of the four treatments. The frequency distribution of the basal area of individuals was estimated by the frequency distribution of classes of interception with the line. Analysis of variance was performed on LAI and basal area data and differences were considered statistically significant when $p < .05$. Species diversity was calculated using the Shannon-Wiener (1963) index for each season and then averaged to obtain an annual estimate. Similarity was calculated using Sørensen's index (Goodall, 1973). Vegetation samples of each treatment were arranged using Bray and Curtis polar ordination (Cottam *et al.*, 1973).

Results and discussion

Total green leaf area index (LAI) ranged between 0.4 and 1.4 throughout the year and small differences in average LAI between the two communities were found (Fig. 1). LAI lower than one is not unusual for natural grasslands. Knight (1973) reported LAI values for the shortgrass steppe in North America between 0 and 0.5. The effect of excluding grazing upon canopy structure was a small increase in annual average LAI of 30% in both plant communities (Fig. 1). Knight (1973) reported no effect of livestock grazing pressure upon total LAI for North American shortgrass steppe.

The major consequence of exclusion was observed on the distribution of leaves in the canopy (Fig. 1). Most of the green material in the grazed area, was concentrated in the 0 – 5 cm layer while in the ungrazed treatment the largest portion of the leaf area was in the 10 – 30 cm layer. Total green biomass showed small differences between ungrazed and grazed areas (Soriano, 1986). Therefore, biomass concentration was higher in the grazed area (2.3 mg cm^{-3}) than in the ungrazed area (0.5 mg cm^{-3}). McNaughton (1984) found a similar response of biomass concentration to grazing in 28 grasslands throughout the Serengeti region. He estimated that a cow-sized animal would be food

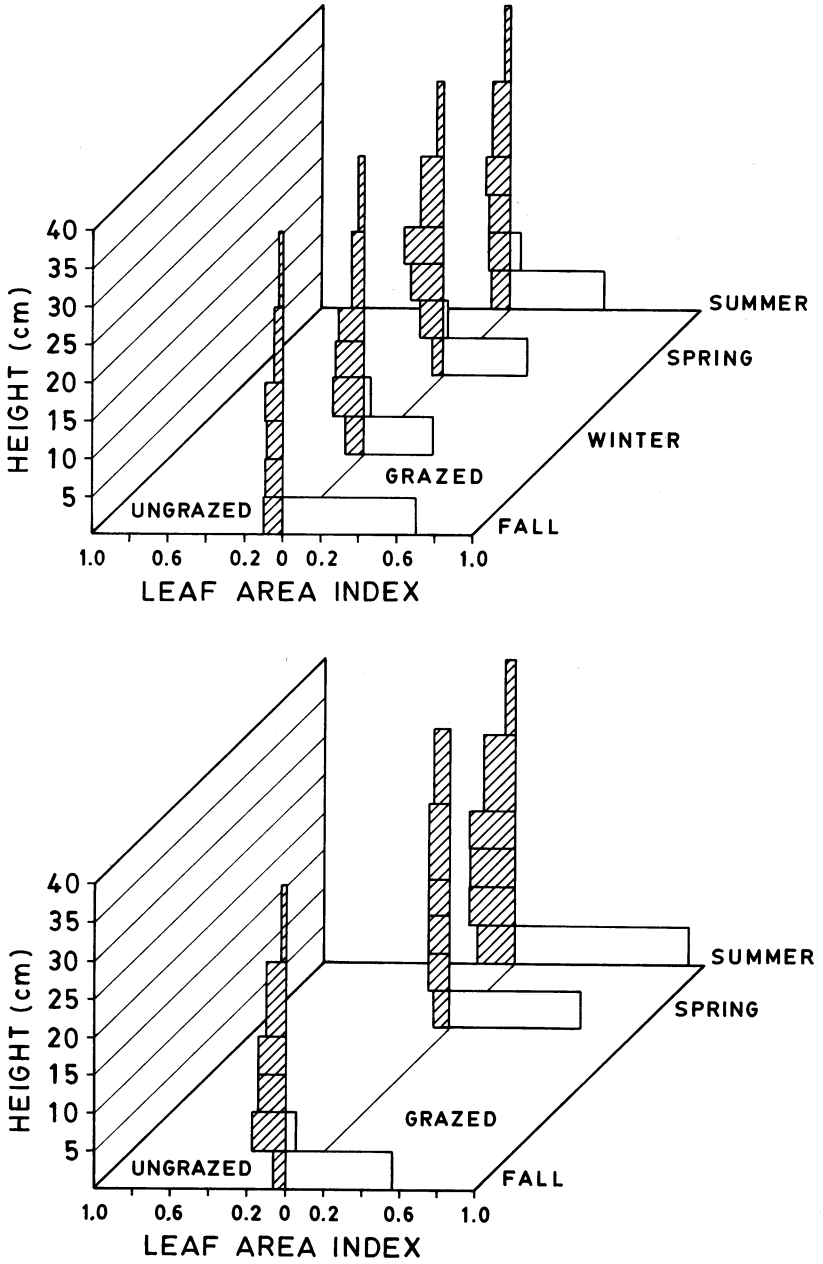

Fig. 1. Leaf area index for different layers from soil level up to 40 cm for the ungrazed areas (shaded bars) and grazed areas (empty bars) along the four seasons. Upper community (upper figure); lowland community (lower figure).

limited in a grassland with a biomass concentration below 0.8 mg cm^{-3}.

Annual average basal area ranged between 18 and 31% for both communities and both treatments. No significant differences were observed between the grazed and ungrazed areas. However, grazing exclusion resulted in an increase of the average interception from 0.5 (±0.01) to 1.5 (±0.4) (Fig. 2). Grazing exclusion resulted in the replacement of a large number of small tussocks by a few

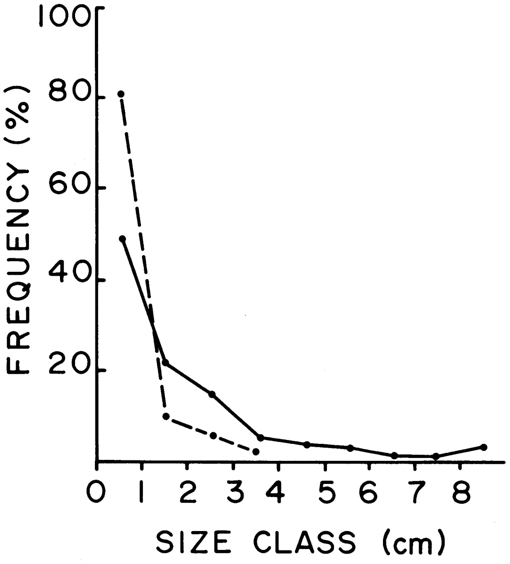

Fig. 2. Frequency distribution of size classes of the interception of individual plants with the line used to estimate basal area. Frequency distribution of size classes of interception is related with the frequency distribution of classes of diameter of individuals at the base level. For the upland community ungrazed areas (−) and grazed areas (- - -).

large ones. The changes in canopy structure may affect the functioning of the grassland. Large tussocks characteristic of the ungrazed treatment represented microsites with high LAI. Deregibus *et al.* (1985) reported that in these microsites, the red:far red ratio of the light reaching the soil level was reduced by 50% in average during the day. Similar changes in light quality were able to reduce the tillering rate of *Lolium multiflorum* plants in the laboratory (Deregibus *et al.*, 1983).

Changes in LAI and basal area observed after grazing exclusion are accounted for by changes in vigor and growth form as well as by changes in species composition (Tables available on request). Monocotyledoneae mainly represented by grasses and a sedge *Carex phalaroides* increased approximately from 65% to 95% of total cover after four years of exclosure. Annuals, both dicots and monocots, were replaced by perennials after a period of exclosure.

The effect of exclosure was an increase in the basal area of the major native perrennial grasses such as *Briza subaristata*; a decrease of a group of native planophile species such as *Phyla canescens* and a drastic reduction of all the exotics. The grazed area supported a larger number of species (42) than the exclosure (17). Most of the exotics in the grazed area were cool-season species originating in the Mediterranean region. These species were very frequent in the grasslands near Buenos Aires during the last century (Vervoorst, 1967). A similar response in canopy structure to grazing for the Serengeti was accounted for by changes in growth form composition (McNaughton, 1979). No exotic species were observed in grazed or ungrazed areas (McNaughton, 1983). In the grasslands of the flooding pampa, which evolved under much lighter grazing conditions than the Serengeti grasslands, structural changes were accounted for by changes in the growth form of native species as well as by the presence or absence of exotic species. It suggests that native grasslands of the flooding pampa did not have enough ecotypes which were adapted to the heavy grazing conditions imposed by Europeans.

The LAI seasonal pattern for the ungrazed areas showed a maximum which occurred in spring for the upland community and in summer for the lowland community (Fig. 1). Species composition differences between both communities may account for the differences in the seasonal pattern. The upland community was dominated by cool-season species which represented 76% of the vegetation cover on an annual average. The lowland community was dominated by warm-season species which had a relative basal area of 62%.

Which are the differences between uplands and lowlands which determine these two patterns of species? The water balance during summer should be more favorable in the swales than in the uplands therefore warm-season species would vegetate in these sites while their growth would be impaired in the uplands. These small depressions, during winter and spring, remain water logged for longer periods of time than the upland making the lowlands a site very unsuitable for the species which concentrate their growth during this period of the year, the cool-season species. Flooded areas may prevent freezing of vegetation under water making the lowlands more favorable for warm-season species which supposedly are more susceptible to low temperature conditions.

At a different hierarchical level, the entire species list of both communities and both treatments were

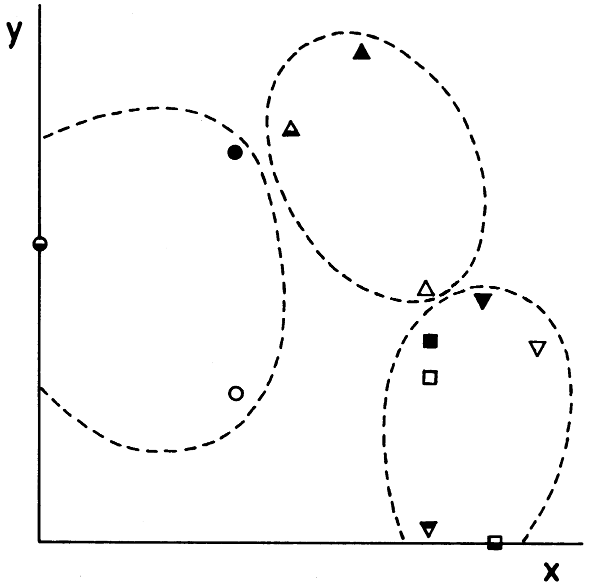

Fig. 3. Ordination of vegetation samples collected in fall (open symbols), in spring (half shaded), and summer (dark symbols) for □ = upland community grazed; ○ = upland community ungrazed; ▽ = lowland community grazed, and △ = lowland community ungrazed.

compared using similarity indices and arranged by the polar ordination technique (Fig. 3). There were large differences between the grazed and ungrazed areas of each plant community as well as between the ungrazed areas of the upland and lowland communities. On the other hand, there were very small differences between the grazed areas of both communities. The lack of grazing allowed to express the differences due to environmental factors such as topography and frequency or duration of floods. Conversely, grazing erased those differences. During the period of exclosure the same group of species decreased in both communities. Two different species groups were adapted to the environmental conditions associated with uplands and lowlands. Allen & Starr (1982) proposed that there are species or groups of species which respond to a fine-grained environmental signal, and outcompete the other species in favorable segments of the environmental gradient. On the other hand, less competitive species might become modal when environmental extremes lower the intensity of competition. These species are often bimodal on the gradient because they are responding to a coarser-grained environmental signal. It is here suggested that the coarser-grained environmental signal is grazing and the fine-grained signal is topography or the environmental characteristics associated with topography.

Diversity was higher on grazed areas (upland community $H' = 3.7$, lowland community $H' = 3.3$) than on ungrazed areas (upland community $H' = 3.0$; lowland community $H' = 2.8$). Higher diversity in grazed areas than in exclosures located in similar sites was also reported by McNaughton (1979) for the Serengeti. The ungrazed areas are envisioned as areas organized under conditions which prevent the attainment of competitive equilibrium (Picket, 1980). Herbivory may act to halt exclusion by competition, creating an environment in which periodically appear patches in the canopy of dominants. Disturbances of this kind which occur periodically determine a higher species diversity than in communities where species can coexist under competitive equilibrium.

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