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PERSPECTIVE

This issue marks the introduction of a new venture for this journal in the form of an arena for discussion and debate. **Perspective** offers the opportunity for the dissemination of viewpoints about the science and management of our biotic, especially rangeland, resources. In this first article, Alex Deregibus and his colleagues argue the benefits of controlled-grazing schemes for the Flooding Pampa grasslands of Argentina. These grasslands appear to have parallels in some respects with the sour grasslands of southern Africa.

Improvement in rangeland condition of the Flooding Pampa of Argentina through controlled grazing

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Abstract

The Flooding Pampa grasslands situated in temperate Argentina were ungrazed historically, but now support primarily breeding herds of cattle. These extensive, flat, infertile grasslands experience seasonal floods. Although summer droughts are usual, grasses maintain productivity during the entire year and produce almost 6 t ha^{-1} a^{-1}. Continuous grazing has caused deterioration of these grasslands in terms of floristic composition and soil properties (salinisation). Stocking rate has been adversely affected. Controlled grazing systems have been applied with the objective of preventing deterioration. The main characteristics of this system are the concentration of animals in large herds, non-selective grazing of dormant vegetation during autumn and winter, and selective grazing during spring and summer. Rotational grazing ensures adequate rest for grazed plants and promotes tillering and establishment of cool season grasses. A system of controlled grazing has shown an improvement in floristic composition and in animal production, despite no increase in primary production. This system should allow for a sustainable utilization of these grasslands.

Additional index words: grasslands, herbaceous production, non-selective grazing, selective grazing, stocking rate

The region and grassland dynamics

One of the two subregions that comprise the extensive temperate humid grasslands in the eastern part of South America is the Pampas (Burkart 1975). The region's flat topography and fertile soils supported the development of a vast livestock and crop industry that bolstered the economy of Argentina and Uruguay during the first part of the century. The increase in the area of cropland destroyed a large proportion of the natural grasslands, and today cattle graze mainly on cultivated pastures and forage crops.

The Flooding Pampa is a lowland area located in the eastern portion of the Pampa subregion (south of Buenos Aires). This extensive plain of almost six million hectares, with shallow soils of low fertility, is dominated by native grasslands (almost 80% of the area). These grasslands are the primary forage source for breeding cattle, which is the main regional activity. The gentle slope of this area results in a low morphogenetic potential. Climate is temperate and humid with an annual precipitation of 900 mm, evenly distributed throughout the year. Topography and rainfall result in recurrent flooding of lowlands and, infrequently, extensive flooding during years of high rainfall. Summer droughts, resulting from both climate and soil conditions, are frequent. Even under these environmental conditions, the sward maintains its productivity during the entire year.

Typical grassland communities in the Flooding Pampa reflect the growth patterns of warm season (C_4) grasses such as *Bothriochloa laguroides*, *Paspalum dilatatum* and *Sporobolus indicus* and cool season (C_3) grasses such as *Briza subaristata*, *Stipa neesiana* and *Danthonia montevidensis*. Topographical position and soil conditions determine different plant communities. Those on the uplands, lying on arable soils, were replaced by crops. Midland and lowland communities occur on shallow and infertile soils, where hydro- and halomorphic conditions are frequent. Midland communities are the most extensive and are dominated by species of *Paspalum*, *Bothriochloa*, *Sporobolus*, *Panicum*, *Stipa*, *Briza*, *Piptochaetium* and *Danthonia*. In lowland areas, two communities are distinguished: a halomorphic (saline) community dominated by *Distichlis spicata*, *Paspalum vaginatum*, *Chloris berroi* and *Hordeum stenostachys*, and a palustric (marshland) community dominated by *Paspalidium paludivagum*, *Leersia hexandra* and *Glyceria multiflora*.

Aboveground green biomass shows very little seasonal variation in ungrazed areas with a maximum green standing crop of 222 g m^{-2} and a minimum green standing crop of 155 g m^{-2}. Annual aboveground primary production is approximately 532 g m^{-2}, and has a clear seasonal pattern in contrast to the small temporal changes in green standing crop. Maximum production occurs in spring and early summer, reaching a rate of 3.1 g m^{-2}, while the minimum rate recorded during early winter is less than 0.31 g m^{-2} (Sala *et al.* 1981a). Two groups of species may be distinguished with respect to their seasonal productivity. Cool-season species have their peak in late winter and spring, whereas maximum production from the warm-season species occurs during summer (Figure 1). In response to the phenological pattern of each floristic group, cattle show a preference for the cool-season grasses from mid-autumn until mid-spring, and switch to warm-season grasses during the other half of the year (Lemcoff *et al.* 1978; Cahuepé & Fernandez Grecco 1981). These two main groups also respond differently to flooding and drought. Cool-season grasses generally had lower values of leaf water potential and showed symptoms of severe water deficit during flooding; warm-season species maintained a more favourable water status during summer and were less affected by flooding (Figure 2; Sala *et al.* 1981b).

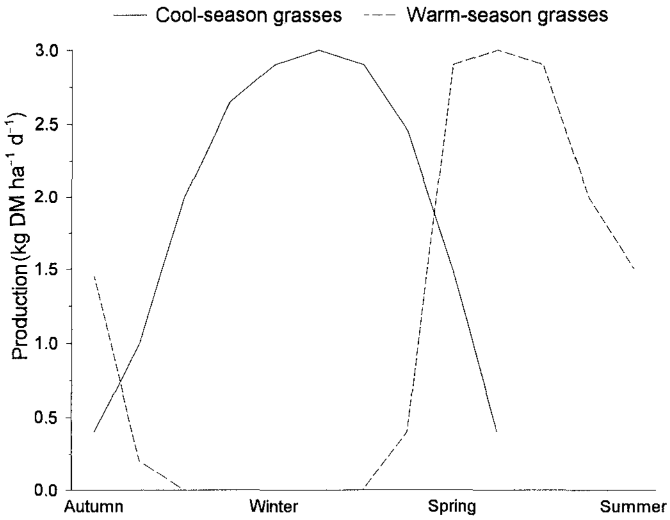

Figure 1 Schematic representation of aboveground net primary production (ANPP) of cool- and warm-season grasses. The relative production rates of the cool- and warm-season grasses are *c.* 1 and 3 kg DM ha^{-1} d^{-1} respectively (from Deregibus & Soriano 1981).

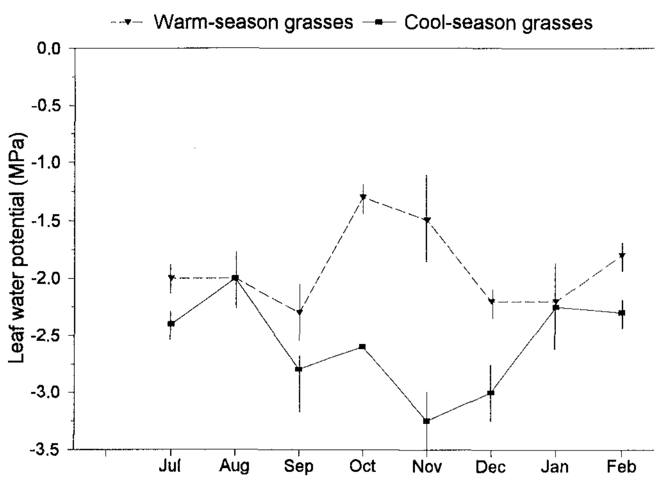

Figure 2 Leaf water potential for cool- and warm-season species at noon. Each data point is the mean (±SE) of nine replications (from Soriano *et al.* 1991).

There appears to be no advantage to replacing native vegetation with cultivated pastures. Floristic studies have shown that exotic species almost disappear while native grass cover increases after a single flooding event (Chanetton *et al.* 1988), improving the forage value of the rangeland. The flood waters have a very low salt content and usually cause a percolation of salts through the top soil horizon. A salinity problem occurs when an area is denuded by overgrazing or mechanical action, which results in a rise in the level of the water table and an increase in the concentration of salts in the top soil (Figure 3).

The problem

These rangelands were ungrazed by large herbivores prior to colonization by the Spanish, but since then cattle have roamed freely although they have become more confined during the last century. Grazing by large domestic herbivores has modified the floristic composition and structure of the vegetation. Important native grasses have been replaced by native planophile species such as *Ambrosia tenuifolia*, *Phylla canescens* or *Eclipta bellidioides*, exotic planophiles such as *Leontodon taraxacoides*, *Mentha pulegium* or *Hypochoeris radicata*, annual grasses such as *Lolium multiflorum*, *Bromus mollis* or *Gaudinia fragilis*, or perennial creeping grasses such as *Cynodon dactylon* (Soriano *et al.* 1991). These floristic changes, indicative of rangeland degradation, have frequently been ascribed to the grazing action of large herbivores. However, we believe that man is indirectly responsible for this degradation trend through his livestock management systems. In traditional management systems the cow herd is confined to a large paddock at the maximum stocking rate for over-wintering. The system does not provide the plant with an opportunity to flower or periods of uninterrupted growth (rest), which inevitably leads to a loss of vigour of the plants. Only when animal performance declines as a result of this process is the stocking rate reduced.

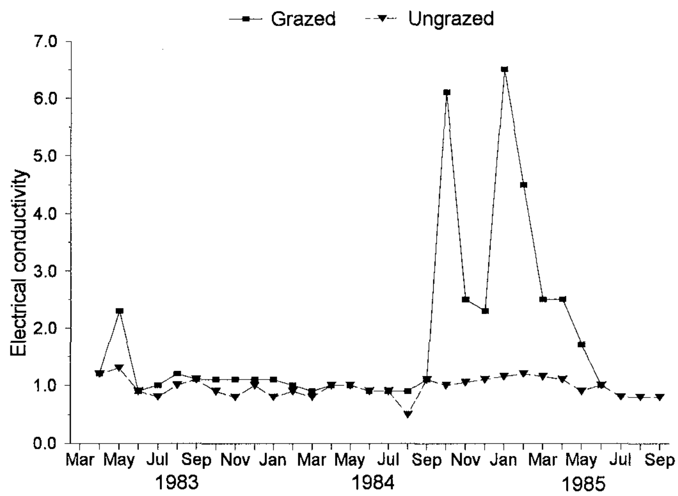

Figure 3 Soil electrical conductivity (dS m^{-1}) of grazed or ungrazed grassland (from Lavado & Taboada 1987).

Deterioration caused by such continuous grazing has led to (1) severe reduction of cool-season grasses which are highly preferred during winter, (2) partial reduction of the production of tall warm-season grasses which are highly preferred during summer, (3) invasion by exotic or native planophiles, annual and creeping grasses, (4) soil denudation and resultant salinisation of top soil owing to a rise in the water table, (5) reduction of stocking rate, animal performance and secondary productivity, and (6) reduced profits. In consequence, the economy and social welfare of the area is negatively influenced.

The solution

An alternative grazing methodology, controlled grazing, has been applied over the last decade in several ranch operations, with the objective of preventing rangeland deterioration. Controlled grazing consists of the following procedures.

(1) Concentrating animals in large herds which are moved through existing paddocks or new subdivisions. The paddock and subdivisions are designed to separate areas of homogenous vegetation. In this way a large proportion of the grazing area is rested, allowing grazed plants an opportunity to regain their vigour.

(2) Non-selective grazing of senescent or dormant C_4 grass vegetation during autumn and winter with dry cows. This intense and slow grazing movement through the paddocks, performed when plant growth is slow and animal nutritive requirements are low, tends to

stimulate tillering and germination, and allow the establishment and growth of cool-season grasses.

(3) Selective grazing during spring and summer by lactating cows. This lenient and fast grazing movement, performed during the season of higher plant growth and nutrient requirement of the animals, ensures maximum animal intake and abundant flowering of plants.

Several evaluations of the effect of this grazing methodology in different plant communities have been made, showing important floristic changes that improve range condition and forage value. In the very fragile and low-producing saline communities an increase in soil cover and floristic diversity was observed (Figure 4). In the more productive and wet lowlands excess summer forage production was reduced and the density and productivity of cool-season grasses was increased (Figure 5). In different places of the Flooding Pampa the following beneficial effects of this methodology have been observed: (1) a reduction of bare soil and an increase of litter cover, (2) a reduction of warm-season creeping grasses and planophile weeds, (3) an increase in the density of tall warm-season and cool-season grasses, and (4) an increase in the density of palustric warm-season grasses in lowlands (Figures 6a & 6b).

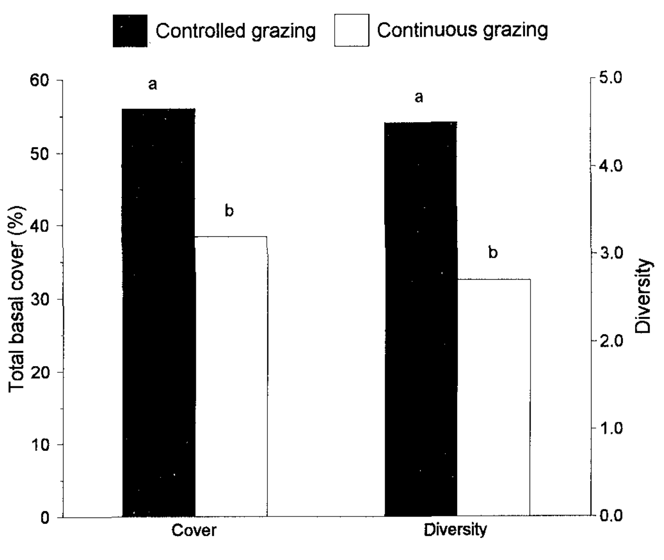

Figure 4 Total basal cover and floristic diversity (Shanon-Weaver index) of saline communities under controlled or continuous grazing. Different letters indicate significant differences (P<0.05) between grazing treatments.

These floristic changes are caused, at least in part, by the reduction of green biomass through grazing pulses, because these grazing pulses alter irradiance in the lower canopy strata. Germination of *Paspalum dilatatum* and *Lolium multiflorum* (Figure 7) and tillering of *Paspalum dilatatum*, *Bothriochloa laguroides*, *Sporobolus indicus* and *Lolium multiflorum* (Figure 8) are promoted when seeds and axillary buds are exposed to the high red/far red ratios of direct sunlight (Deregibus *et al.* 1985, 1994; Casal *et al.* 1985, 1987).

The application of controlled grazing has usually resulted in an immediate increase of the stocking rate of about 30% as a consequence of the better distribution of animals and utilization of residual forage, and because cool-season grasses are allowed a chance to establish and grow before being grazed. Further improvements to range conditions which limit range carrying capacity, such as increases in winter forage production, allow a further 50–70% increase of stock numbers. Because the investment required for such systems is minimal (some electric fences and water point improvements are needed to run a cow herd of 500–700 animals), the increased production has a major impact on the profitability of the ranching enterprise (Table 1).

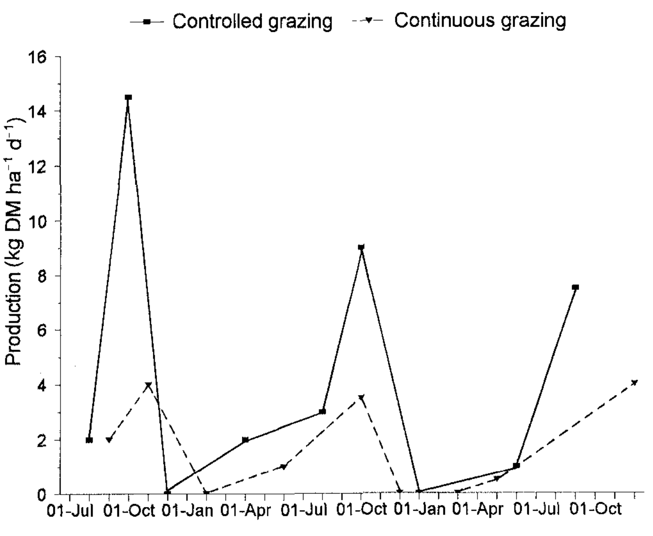

Figure 5 Aboveground net primary production (ANPP) of cool-season grasses under controlled or continuous grazing.

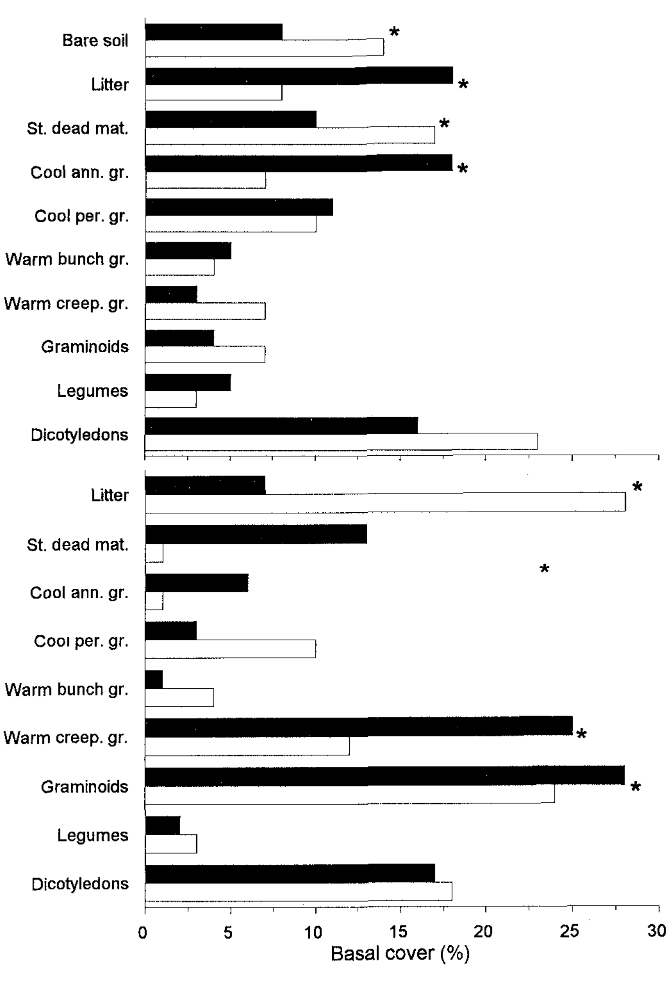

Figure 6 Proportion of basal cover of different groups of species, litter cover and bare soil under controlled (solid bars) or continuous grazing (empty bars) in a midland community (a) and in a lowland community (b). Significant differences (P<0.05) between grazing treatments are indicated by asterisks.

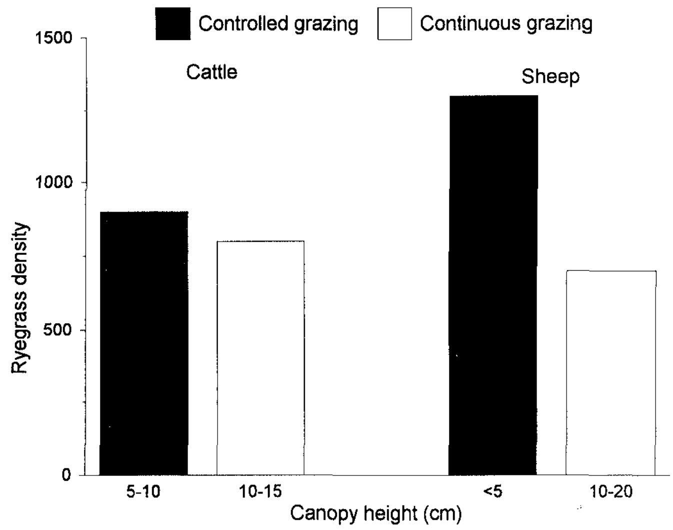

Figure 7 Density of ryegrass seedlings derived from seeds placed at the bottom of grassland canopies under controlled or continuous grazing performed by cattle or sheep. Remnant canopy heights after grazing are indicated (from Deregibus *et al.* 1994).

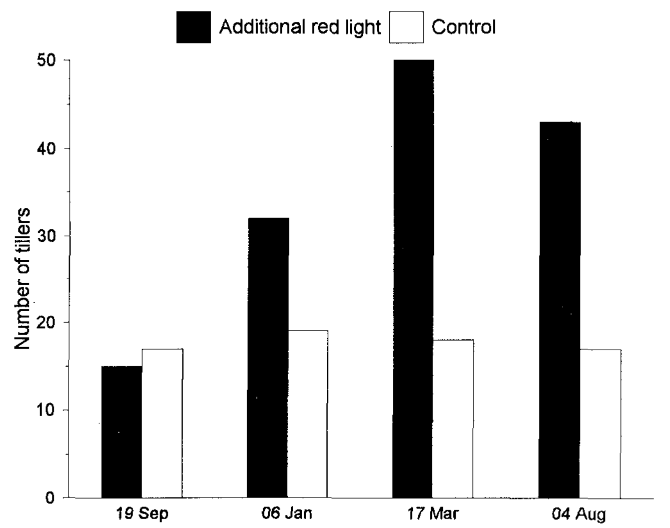

Figure 8 Tiller population per plant of (*Paspalum dilatatum*) Dallis grass as affected by increased red light beneath the canopy. Significant treatment differences (P<0.01) are indicated by asterisks (from Deregibus *et al.* 1985).

Table 1 Variation in the economical indices of a ranch of the Flooding Pampa before and after four years of controlled grazing (from Rodríguez & Jacobo 1994)

Attribute	1990	1994
Ranch area (ha)	1 783.00	1 783.00
Stocking rate (EV ha^{-1})	0.49	0.77
Meat production (kg ha^{-1} a^{-1}	66.40	105.20
Net income (US $ ha^{-1})	44.17	69.95
Variable costs (US $ ha^{-1})	8.55	16.09
Gross margin (US $ ha^{-1})	35.61	53.86
Structure expenditure (US $ ha^{-1})	40.00	40.00
Net result (US $ ha^{-1})	-4.40	14.00
Livestock capital (US $ ha^{-1})	117.67	186.38
Liquid capital (US $ ha^{-1})	48.55	56.09
Land capital (US $ ha^{-1})	350.00	350.00
Total capital (US $ ha^{-1})	516.22	5 925.47
Rentability (%)	-0.85	3.34

Further comments

Our experience has shown that, through controlled grazing, it is possible to achieve a sustainable utilization of the Flooding Pampa grasslands in Argentina. This contrasts with a number of reports that found no significant benefit in applying rotational grazing techniques (Heitschmidt *et al.* 1987; Hart *et al.* 1989; Walker & Heitschmidt 1989). We argue that these grazing techniques may prove beneficial whenever a number of important forage-producing species benefit from them. In the Flooding Pampa rangelands, where winter forage production limits range carrying capacity, the crucial effect of controlled grazing is the promotion of the density and vigour of cool-season grasses.

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