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Continuous feral horse grazing and grazing exclusion in mountain pampean grasslands in Argentina

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ABSTRACT

This paper evaluates changes in the composition and structure of plant communities and plant functional groups associated with the continuous presence of feral horses in mountain pampean grasslands in Argentina in order to explore the potential effects of horse removal on vegetation restoration. Specific and functional richness, diversity, evenness, spatial heterogeneity and above-ground biomass were compared between areas subjected to ten years of intensive grazing by horses and exclosures of the same age. Forbs, shrubs and rosettes were more abundant after ten years of grazing, while the spatial heterogeneity of perennial grasses was higher in long-term grazed areas. Nevertheless, grasslands showed good recovery after horse removal, with greater species diversity and evenness, higher abundance of perennial grasses, greater above-ground biomass and lower percentages of exotic species. An understanding of the effect of feral animals on plant communities will lead to the design of a strategy of adaptive management and monitoring tools for measuring the condition of grasslands.

1. Introduction

Grazing by large herbivores has an affect on grasslands (Dyer et al., 1993). Direct effects include selective defoliation that results in morphological and physiological alterations of plants and in the reduction of their reproductive capacity and competitive ability. Indirect effects include changes in soil characteristics, nutrient cycles and soil water availability (Archer and Smeins, 1991; Sternberg et al., 2000). Alterations in the distribution of plant species modify habitat diversity (Adler and Lauenroth, 2000; Wang et al., 2002) that might make an impact on the abundance and reproductive success of small mammals, birds and insects (Milchunas et al., 1998; Hobbs, 2001; Zalba and Cozzani, 2004), change interactions between coexisting species (Vázquez and Simberloff, 2003) and modify disturbance regimes, ecosystem resistance and resilience properties (Prieur-Richard and Lavorel, 2000; Holmgren, 2002).

The effect of introduced herbivores on the composition and structure of grasslands may vary, depending on the intensity and frequency of grazing and the evolutionary relationship between grasslands and grazers (Milchunas et al., 1988). Ecosystems that have evolved under low grazing pressure, like most South American grasslands, are more vulnerable when they are overgrazed, compared with those that included large hooved congregating mammals, like bovids and sheep, in their evolutionary past (Milchunas et al., 1988; Mack, 1989; Cingolani et al., 2005). Native herbivores differ from domestic livestock and feral herbivores due to differences in their spatial and temporal patterns of plant resource-use (Archer and Smeins, 1991). Moreover, these alterations are more severe in the case of feral herbivores since they are free-ranging and non-managed, which differs from the typical situation of cattle ranching. Most exotic herbivores are artificially maintained at high concentrations in limited areas where fences prevent their emigration when the abundance of desirable forages decreases, resulting in the overgrazing of preferred plants (Archer and Smeins, 1991; Holmgren, 2002). As a result, self-sustained perpetuation of unmanaged exotic herbivore populations may result in ecological effects that are different to those extensively studied for cattle and which could pose serious concerns for the conservation of plant communities (Huntly, 1991; Loucougaray et al., 2004).

The presence of feral horses and donkeys is a common management problem in natural or semi-natural grasslands in many countries (Duncan, 1987; Beever and Brussard, 2000a; Department of the Environment and Heritage, 2004; Linklater et al., 2004; Rheinhardt and Rheinhardt, 2004) and efforts for restoring the structure and composition of affected communities are becoming more and more common (Dobbie et al., 1993; Olson-Rutz et al., 1996a; Bastian et al., 1999; Beever and Brussard, 2000b; Loucougaray et al., 2004; Dawson et al., 2006). It is important to evaluate the effects of

Abbreviations: CV, Coefficient of variation; ETPP, Ernesto Tornquist Provincial Park; NMDS, Non-parametric multidimensional scaling analysis.

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feral herbivores in wild-lands from this perspective and to assess the reversibility of their impacts once they are removed. Some studies have evaluated the effect of continuous intensive grazing by feral horses on the species composition of natural grasslands (Duncan, 1987; Rogers, 1991) and there is evidence that the presence of feral horses affects grass performance (Kristensen and Frangi, 1992; Loydi and Zalba, 2009) as well as bird communities (Zalba and Cozzani, 2004) in mountain pampean grasslands in Argentina. However, as far as we know, no previous study has considered the dynamics, abundance and distribution of plant species following horse removal.

An understanding of the responses of vegetation to long-term, continuous grazing and grazing cessation is critical in order to facilitate the management of mountain grasslands for both biological conservation and sustainable use. Therefore, the objective of this study was to evaluate the resulting changes in the composition and structure of plant communities and plant functional groups associated with continuous grazing by feral horses in mountain pampean grasslands and to explore the potential effects of vegetation restoration after the removal of exotic ungulates. We evaluated the composition (species richness and diversity), abundance and spatial patterns of plant functional types (life forms and growth forms) and the percentage cover of bare ground to clarify whether any changes occur in the grassland in response to the contrasting grazing histories and to improve the management of mountain pampean grasslands. In order to do this the vegetation composition of mountain grasslands was compared after ten years of intensive grazing (1993–2003), and also with that in exclosures (1997–2003), in a nature reserve invaded by feral horses.

2. Materials and methods

2.1. Study site description and grazing history

This study was carried out in the Ernesto Tornquist Provincial Park (ETPP), established in 1942, one of the last relicts of pampean grasslands in a relatively good state of conservation (Cabrera, 1976; Bilenca and Miñaro, 2004). ETPP is located in the Ventania mountain range in the central Pampas region, between 38° 00′ and 38° 10′ S, and 61° 45′ and 62° 08′ W. It has an area of ca. 6700 ha, and includes some of the highest peaks in the region, reaching up to 1200 m. Climate is temperate, with an average annual temperature of 14 °C (Burgos, 1968). Average precipitation is 800 mm, falling mostly in spring and autumn, with occasional snow-fall in the winter. The mean air temperature was 13.5 °C and mean annual precipitation 686 mm, ranging from 583.5 (1995) to 1154 mm (2001), over the period considered in this study (1993–2003). The region belongs to the Southern District of the Pampas Phytogeographic Region, where grass steppe is the dominant vegetation (Cabrera, 1976) and *Stipa*, *Piptochaetium*, *Festuca* and *Briza* are among the most common grass genera. There are also less frequent shrub communities dominated mainly by *Eupatorium buniifolium*, *Discaria longispina* and *Geoffroea decorticans* (Kristensen and Frangi, 1995; Long and Grassini, 1997). In pre-hispanic times native herbivores in this region included Pampas Deer (*Ozotoceros bezoarticus*) and Guanaco (*Lama guanicoe*). The former became extinct in the region early in the 20th century, while guanacos still remain but in extremely low numbers (Chébez, 1994). Cattle were introduced to the Pampas at the end of the 15th century and were rapidly adopted by the Indians, becoming abundant in the 18th century in some areas of the Pampas (Brailovsky and Foguelman, 2006). Other exotic herbivores of medium size were introduced to the area in the 19th century for hunting: Red deer (*Cervus elaphus*) and Fallow deer (*Dama dama*). Nevertheless, the main impact of exotic ungulates in the study area probably started much later: in 1942 five horses were released in the reserve with the aim of maintaining a "native" breed (*caballos criollos*). Since then, the population has increased by 6% p.a. and horses have become the main herbivore in the area, reaching a population of 700 horses. However, the abundance of other exotic and native ungulates has decreased due to predation, sickness, migration and competition with horses and they have almost disappeared from the area (Scorolli, 2007). During our sampling period horse densities ranged from 0.20 horses ha^{-1} (1993) to 0.35 horses ha^{-1} (2003) (Scorolli, 2007).

2.2. Sampling

All study areas were located on adjacent piedmont grasslands, with 5–11% steepness of warmer, preferentially grazed, north-facing slopes, characterized by shallow soils and occasional rocky outcrops. Grazed areas included three valleys of 27, 23 and 18 ha under continuous intensive grazing by free-ranging feral horses. The three grazed areas were sampled in two sampling periods, the springs of 1993 and 2003. In 2003, two exclosure areas, where horses and others ungulates were excluded by perimeter fences, were added to the analysis. The exclosure areas were two sections, of 15 and 12 ha respectively, of the first two previously described valleys that have been protected from feral horses since the beginning of 1997. The exclosure areas were not sampled in 1997, so the records obtained in 1993 were used as a reference of the state of the grassland condition, as well as to evaluate 7 years of horse exclusion and 10 years of continuous grazing treatments. In spring (late November–early December) 1993 and 2003, 20 plots of 1 m^2 were randomly distributed each time in the study areas, and the frequency (presence/absence) of each plant species present in each plot was recorded. Species richness, Shannon's diversity (Krebs, 2001) and evenness (Pielou, 1975) were calculated for each study area in both sampling periods.

Species with similar biological traits, such as growth form (erect or prostrate) and life cycle (annual or perennial), that are notable for their response to grazing (Vesk and Westoby, 2001) were grouped together. The abundance of the resulting functional groups were calculated from the frequency of each species recorded in the 20 randomly distributed plots (1 m^2) in each study area for both sampling periods. The corresponding coefficient of variation (CV) of each functional group was calculated for each grazing treatment: reference condition (grazed areas sampled in 1993), 10 years of continuous grazing (grazed areas sampled in 2003) and 7 years of horse exclusion (exclosure areas sampled in 2003) for both sampling periods. The CV was used as an indicator of the changes in spatial pattern for each functional group between grazing treatments (Sokal and Braumann, 1980; Sternberg et al., 2000; Veen et al., 2008).

Above-ground grass and forb biomass was estimated at the end of the rainy season in 2003 (spring) by drying and weighing the herbaceous standing crop clipped from five 1 m^2 randomly distributed plots in each study area. The percentage of bare ground was estimated in 20 plots (1 m^2) randomly distributed in the exclosure and grazed areas sampled in 2003 using the canopy-cover method of Braun Blanquet (Mueller-Dombois and Ellenberg, 2003).

2.3. Data analysis

Patterns of variation in species composition in the studied areas were analyzed using the non-parametric multidimensional scaling test (NMDS) based on a matrix of Euclidean distance calculated from the frequency of each plant species in each grazing treatment, in which stress values were minimised. Species present in less than 5% of the plots were excluded from the analysis in order to reduce the influence of rare species (Legendre and Legendre, 1998; Legendre and Gallagher, 2001). We performed a Mantel test to determine whether the vegetation groups obtained from NMDS analysis were significantly different. We undertook a Spearman correlation