

Pampas deer conservation with respect to habitat loss and protected area considerations in San Luis, Argentina

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Abstract

Ozotoceros bezoarticus celer is the most endangered subspecies of pampas deer. Although common in the Argentine Pampas 100 years ago, it persists in only two small populations. The largest population has survived due to the rarity of roads, internal farm subdivisions, and the low cattle density. However, habitat condition for this population has changed dramatically in the last 16 years. Five Landsat images (1985, 1992, 1997, 1999, 2001), covering 4608 km², were used to quantify pampas deer habitat loss due to the replacement of natural grassland by exotic pastures and crops. Image classification showed that natural grassland cover was reduced from 84.5 to 37.8% between 1985 and 2001. The annual transformation rate increased significantly from 1.4 to 10.9%. Average paddock size was significantly reduced from 1470 to 873 ha, and the number of paddocks increased from 129 to 227. The land within this area proposed for a national park has not escaped these habitat changes. In the last 6 years the amount of replaced area within the proposed park has increased from 9.1 to 51.1% due to actions by ranchers to avoid inclusion within park boundaries. Three patches of natural grassland still remain within the pampas deer distribution, one of which is the proposed national park. The implementation of a national park is a decisive challenge for the survival of pampas deer and its habitat in Argentina.

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1. Introduction

The pampa in Argentina, and campos in Brazil and Uruguay constitute the greatest grassland ecosystem in South America and one of the few grassland ecosystems present in wet temperature areas worldwide (Soriano et al., 1991). In Argentina, the pampa ecosystem covers 460,000 km² in the central eastern part of the country (Cabrera, 1976; Burkart et al., 1994). In the past 150 years this ecosystem was severely transformed by agriculture and cattle breeding, with a continuous advance of the agricultural frontier from the humid east to the semiarid west (Anderson, 1979; Leon et al., 1984; Viglizzo et al., 2001). Analysis of the conservation status of eco-regions in Latin America designate the pampa region as endangered and of maximum priority due to its great transformation, biological uniqueness, and the

absence of protected areas (Burkart et al., 1994; Dinerstein et al., 1995).

Ozotoceros bezoarticus celer is the southernmost and most endangered subspecies of pampas deer (Wemmer, 1998; Dellafiore and Maceira 1998). It is endemic to the Argentine Pampa Region and is the only deer species directly associated with open grassland in this country. The geographical retraction of the grassland has coincided with a decrease of the population of pampas deer (Maceira et al., 1996). Originally distributed across the pampa of Argentina (Cabrera, 1943), today its population has suffered a dramatic decline due to habitat transformation and fragmentation, hunting, and probably competition for forage (Jackson and Giullietti, 1988) and transmission of infectious diseases (Jungius, 1976) from cattle. At present, only two small populations persist at the eastern and western margins of the pampa region. The western population, located in the San Luis Province, is the largest both in population size and area covered.

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Pampas deer are distributed across 4500 km² in San Luis Province. However, most animals are concentrated within 1450 km², where extensive natural grasslands still can be found (Demaría et al., 1995, 1996; Maceira et al., 1997). A survey using terrestrial and aerial censuses, and personal interviews with local farmers, estimated that 500–1000 deer remained in this area (Dellafiore, 1997). Pampas deer have probably persisted in San Luis due to the peculiar characteristics of these grasslands. The area is composed of large private ranches used primarily for cattle breeding. The absence of roads and crop agriculture, the minimal internal subdivision on the ranches, the historically low cattle density, and the economically conservative attitude of some farmers, have all contributed to deer survival in this region. A previous study examining deer density and ranch characteristics showed that the presence/abundance of deer was positively associated with ranch size and presence of natural grassland, and negatively associated with the amount of exotic grasslands, crop cultivation, stocking rate and degree of internal fencing of the ranch (Dellafiore et al., 2001).

Natural grasslands in San Luis Province are the last great pampas deer habitat in Argentina, and the perception of local biologists is that the habitat condition of the area is rapidly changing (Demaría et al., 1996). The source of this change is the conversion of natural grasslands into exotic grasslands that are dominated by *Eragrostis curvula* and *Digitaria eriantha*. These species are considered beneficial by ranchers because they allow increased cattle stocking rates. However, exotic grasslands, or their indirect effects, are not favorable to pampas deer. Although the conversion pattern and rate of these grasslands might be important to wildlife biologists charged with monitoring pampas deer habitat, it is a difficult feature to measure because of the scale of the area, lack of adequate roads, and the lack of published habitat surveys that allow comparisons with past decades. The purpose of this study is to use remote sensing technology to quantify the amount of natural grasslands remaining for pampas deer, and to use past and present images to document the pattern and rate of change for these grasslands over the last 15 years.

2. Methods

2.1. Study area

The study was conducted in 4608 km² in the south-central portion of San Luis Province, the center of western deer population (Fig. 1). This area is composed of two different phytogeographic regions: the pampa and monte (Cabrera, 1976). The phytogeographic region of monte covered an area of 454.54 km² (9.9%) on the western section of the study area, with the remaining pampa region covered an area of 4153.54 km² (90.1%).

The monte region is predominately forest and shrub composed of *Prosopis flexuosa*, *Larrea divaricata*, and *Geoffroea decorticans*, and is not suitable habitat for pampas deer. The San Luis pampa belongs to the semi-arid western extreme of the pampa grassland (Leon and Anderson, 1983), and is characterized by sandy soils and rolling hills, with fixed and live dunes (Anderson et al., 1970). Annual average rainfall is 450 mm, concentrated between October and April. Absolute maximum summer temperatures can reach 43 °C, while in winter temperatures can descend to –15 °C.

Anderson et al. (1970; Anderson, 1979) described the western extreme of the pampa region as grassland with islets of tree species, such as *Geoffroea decorticans*, *Prosopis caldenia* and *Prosopis alpataco*. *Sorghastrum pellitum* is the dominant grass species in the climax vegetation; it has been used to indicate superior stages of the ecological succession (Anderson, 1979). Other grasses associated with *S. pellitum* are: *Elyonurus muticus*, *Bothriochloa springfieldii*, *Chloris retusa*, *Schizachyrium plumigerum*, *Eragrostis lugens*, *Sporobolus subinclusus*, *Aristida spegazzini*, *Poa ligularis* and *Poa lanuginosa*. At present these grasslands are not uniform, as composition varies according to their management history (Anderson, 1979; Aguilera et al., 1998).

Exotic grasslands are composed of *Eragrostis curvula* and *Digitaria eriantha*. Both are species which originated in Africa and were introduced in the region to increase livestock carrying capacity on the ranches. *E. curvula* was introduced in the 1940s, and its sustainability and profitability has been largely tested in the region (Marchi et al., 1974; Covas and Cairnie, 1985). *D. eriantha* is a new pasture in the area, and livestock carrying capacity and sustainability is still undergoing testing by researchers (Frassinelli et al., 1992).

The study area was divided into two zones based on the abundance of pampas deer, as defined by Demaría et al. (1995) and Dellafiore (1997) (Fig. 1). These authors estimated the distribution and abundance of pampas deer in the region by means of interviews with ranch owners or managers, and both air and land censuses in three different seasons during 1995–1997. The “Abundant” zone included all the ranches that showed a deer density greater than 0.40 deer/km² during the aerial and terrestrial census (Dellafiore, 1997). The “Scarce” zone included the ranches where pampas deer were not present or sporadically present according to rancher interviews.

The area selected for a national park is located in the northwestern section of the study site. The 12,000 ha park is within the San Luis pampa grassland ecosystem and the abundant pampas deer zone. Natural grassland covers 94.5% of the potential park and is rated as very good conservation state with regards to species richness and cover (Demaría et al., 1996).

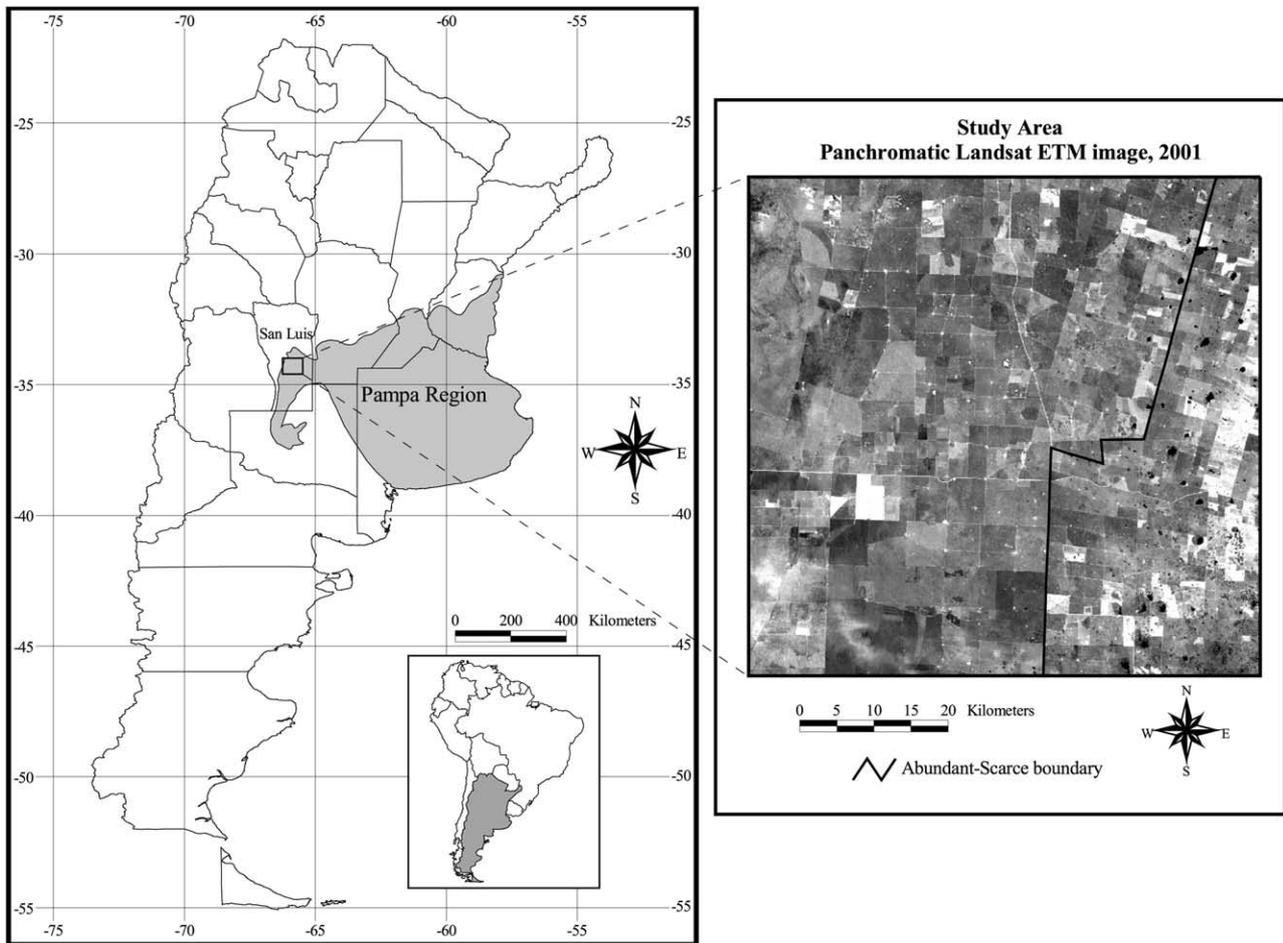


Fig. 1. Location of study area in the semi-arid westernmost portion of the pampa grassland region, San Luis, Argentina. The image on right shows the entire study area, including livestock paddocks and the boundary between the eastern (scarce deer zone) and western (abundant deer zone) study areas.

2.2. Image analysis

Habitat abundance and rates of loss were measured using Erdas Imagine 8.4 and Arcview 3.2 to determine grassland type, paddock size and distribution. Satellite sensor data from four Landsat Thematic Mapper (TM) images (1985, 1992, 1997, 1999), and one Landsat Enhanced Thematic Mapper Plus (ETM+) image (2001) of the study area were utilized covering a period of 16 years. The spatial resolution of these images was 28.5 m.

All images were acquired during the wet season from October to April. The 1985 image was geometrically corrected by the United States Geological Survey prior to purchase and all other images were registered to the 1985 image using an image-to-image registration procedure with nearest neighbor resampling (Jensen et al., 1993). The root mean square error (RMS) was less than a pixel (Average RMS = 0.591 ± 0.05) for all registrations.

The landuse classification of the images was determined through an unsupervised classification using the chain algorithm or ISODATA with 60 clusters. For each image these 60 clusters were classified into four

landuse categories: Grassland, Replaced Area, Forest, and Lagoons. Replaced Area included both annual agricultural crops and exotic perennial pastures. Cluster busting, as described by Jensen (1996), was then used to separate classes that remained mixed after the previous classification. The digital numbers of the grassland varied according to recent land use, as recently burned grassland areas, overgrazed paddocks, and resting cow zones reflected differently, even when the grass species composition was similar. A mask was applied to select areas from a corresponding raster file and we developed a supervised classification for the mixed clusters using the Parallelepiped Classification Algorithm (Jensen, 1996). Training sites were selected using historical data obtained from published (Anderson et al., 1970; Aguilera et al., 1998) and unpublished sources including interviews with the owners or local managers of the ranches located in the study area. All of the images were then corrected via visual interpretation, an Analog Image Processing method described by Lillesand and Kiefer (1994).

An error matrix was created to test the accuracy of the 2001 image classification (Jensen, 1996). A stratified

random sampling algorithm within Imagine was used to select 50 sample points in the study area. Test sites were visited using global position system (GPS) instruments (Trimble Geoexplorer II) and sampled in May 2002. We assumed that the accuracy of the historical images was similar to the 2001 image, as the same classification methods were used to classify all the images.

The loss of pampas deer habitat was estimated using a post-classification method of comparing each classified image to the previous image of the study area. In addition, the last image (2001) was compared to the first image (1985) to quantify change over the entire period. Besides comparing subsequent images, a knowledge-based classification, via the Erdas Knowledge Engineer, was applied to the classified images to identify the grassland areas that have remained unchanged in all of the images. A linear regression analysis was used to examine grassland cover variations from 1985 to 2001, and the annual transformation rate over that period.

2.3. Paddock fragmentation and ecological condition

To determine the changes in number and area of the paddocks, Arcview was used to digitize maps from the 1985 and 2001 images. Only ranches within the “Abundant” region of the study area and covered by air census (Dellafore, 1997) were digitized. In a 1996 study (Demaría et al., 1996), the ecological condition of each paddock was measured in the area selected for a national park and buffer area (Fig. 2). The ecological condition (Molinero et al., 1996) was a relative index based on the climax species composition and productivity of the grassland expected under normal climate and best practical management. The climax community was determined from Anderson (1979), and a model of condition and management of rangeland based on site and condition classes (Dyksterhuis, 1949, 1958). A visual estimation was made in each paddock to determine grass species present, the amount of bare soil and cattle impact. Based on this evaluation, each paddock was placed in one of five ecological condition grades: excellent, very good, good, regular, or poor. Arcview was used to measure the area covered by each category in 1996. The changes in grassland categories areas from 1996 to 2001 was measured by overlaying the category map and image classifications. Analysis of variance was used to examine paddocks size differences between 1985 and 2001.

3. Results

3.1. Image classification

The overall accuracy of the 2001 image was 94.5%. The producer’s accuracy (error of omission) was 100,

100, 87, and 100% for the lagoon, forest, grassland and replaced categories, respectively. The user’s accuracy (error of commission) was 100, 100, 100, and 88% for the lagoon, forest, grassland and replaced categories, respectively. The overall Kappa Statistic was 0.9.

3.2. Change detection

Of natural grassland 2178.4 km² were transformed to crops or exotic grasslands from 1985 to 2001 (Fig. 2), with significantly less natural grasslands detected for each sample over that period ($F=26.91$; d.f. = 1, 4; $P=0.014$; $r^2=0.90$). The period of 1997–1999 experienced the greatest annual loss of natural grasslands (Table 1). Relative to the amount of natural grassland remaining, the highest proportion of grassland was lost during the last period (1999–2001) (Table 1). Although native natural grasslands were the most abundant land type in 1985 (84.5%), exotic grasslands composed greater than 82% of the study area by 2001 (Fig. 3). The annual transformation rate increased significantly from 1.4% in 1985–1992 period to 10.9% in the period from 1999 to 2001 ($F=27.74$; d.f. = 1, 3; $P=0.034$; $r^2=0.93$) (Table 1). The knowledge classification model estimated 1694.5 km² (37.8%) of the natural grasslands maintained their land-use type throughout the study period.

3.3. Abundant versus scarce pampas deer zone

The zone where pampas deer were abundant in 1995–1997 covered 2885 km² in the western side of the study area, with deer scarce or not present in the remaining 1268 km² (Fig. 1). Throughout the period, the scarce zone had a lower proportion of natural grasslands than the abundant zone (Table 1). Prior to 1992, the replacement of natural grassland occurred primarily in the zone where pampas deer were scarce (Table 1). Since 1992, the replacement of the natural grassland increased significantly in both zones, dropping the percentage of natural grassland in the abundant zone from 91% in 1992 to 62% in 1999 (Table 1). In 2001 there was more exotic than natural grasslands in both zones (Table 1; Fig. 3).

3.4. Paddock subdivision

Paddocks were examined in the same area (1895.5 km²) in both 1985 and 2001. The number of paddocks increased from 129 in 1985 to 217 in 2001. The average size was significantly reduced from 1470 ha in the year 1985 to 873 ha in 2001 (ANOVA $F=31.11$; d.f. = 1, 344; $P<0.001$). In 1985, 57.7% of the paddocks were greater than 1000 ha, covering the 82.5% of the total area. In 2001, these large paddocks were reduced to 28.1% of the total number, covering the 64.4% of the area (Table 2).

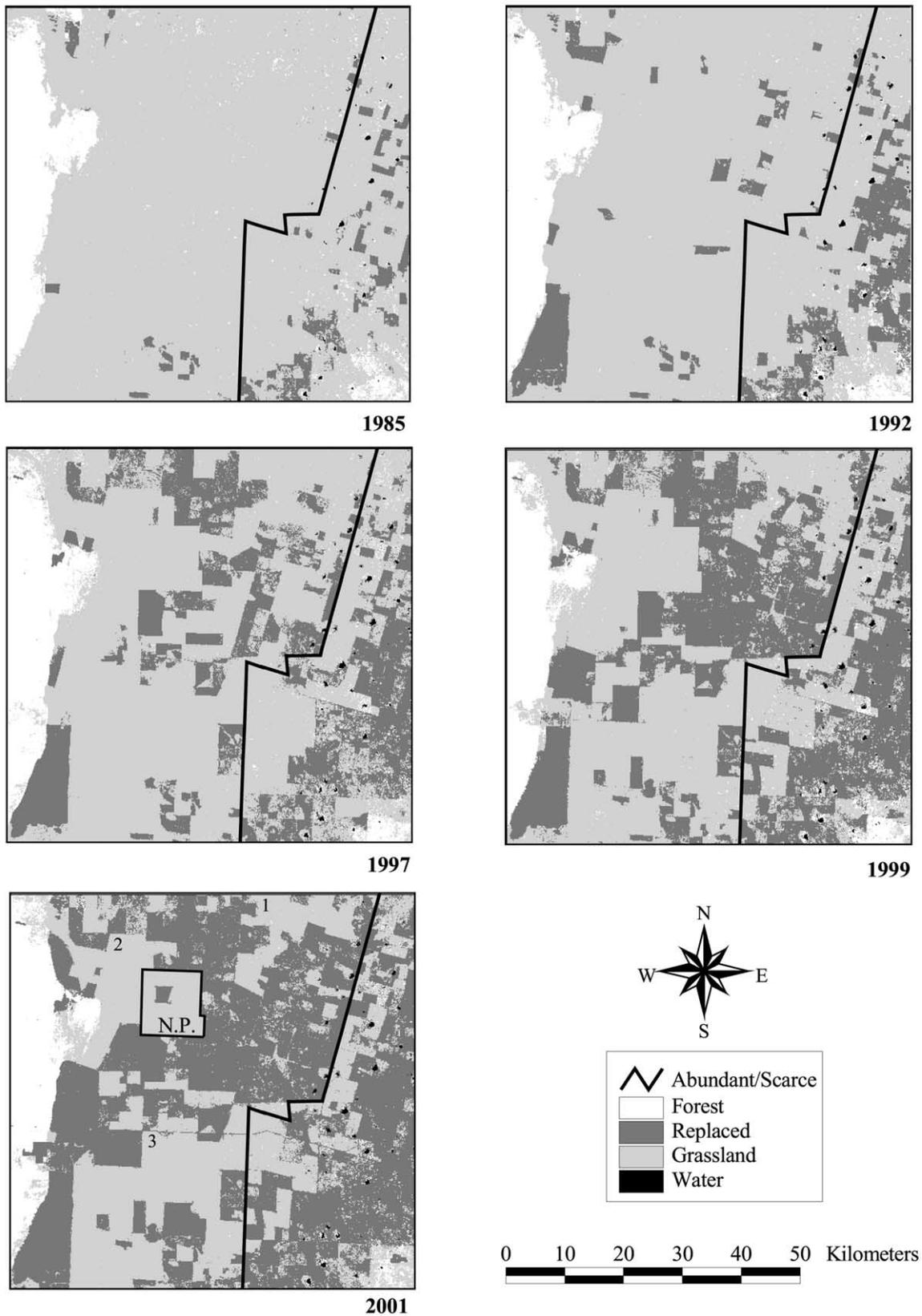


Fig. 2. Land use classification of the study area in San Luis Province, Argentina, for 5 years (1985, 1992, 1997, 1999, 2001). The division between eastern and western study areas is shown on each image. The 2001 image shows the proposed location for a new national park (N.P.) and the three large areas of natural grasslands discussed in the text are indicated with numerals.

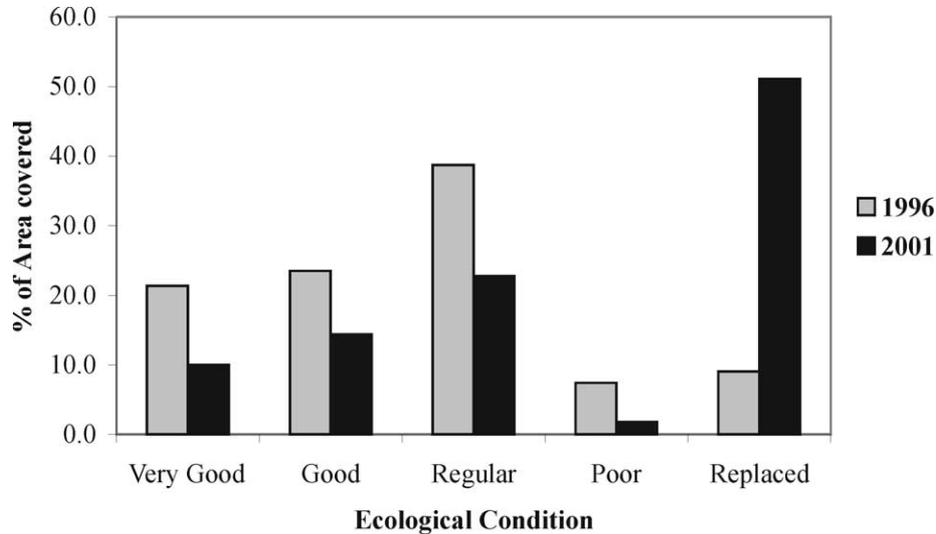


Fig. 3. Percentages of area covered by each ecological condition categories in 1996 and 2001.

Table 1

The amount and percentage of natural grassland converted to crops or exotic grasslands in each period from 1985 to 2001, and amount of natural grassland in the western (deer abundant) and eastern (deer scarce) zones for each image in San Luis Province, Argentina. The “Monte” phytogeographic region was not included when calculating the percentages

Image date	Grassland converted during period (km ²)		Western study area (km ²)		Eastern study area (km ²)	
	Total	Per year	Grassland area	Replaced area	Grassland area	Replaced area
1985			2823.3 (98%)	46.6 (2%)	1047.8 (83%)	142.9 (11%)
1992	374.5 (9.6%)	53.5 (1.4%)	2628.2 (91%)	241.8 (8%)	865.4 (68%)	313.1 (25%)
1997	689.1 (19.6%)	137.8 (3.9%)	2173.5 (75%)	703.3 (24%)	728.4 (57%)	456.7 (36%)
1999	592.8 (20.3%)	296.4 (10.2%)	1794.0 (62%)	1133.1 (39%)	580.2 (46%)	591.1 (47%)
2001	522.0 (21.9%)	261.0 (10.9%)	1404.5 (49%)	1508.1 (52%)	454.9 (36%)	750.2 (59%)

Table 2

Number and size of ranch paddocks in 1985 and 2001 within abundant deer zone in San Luis Province, Argentina

	1985	2001
Number of paddocks	129	217
Number of large paddocks (> 1000 ha)	68 (52.7%)	61 (28.1%)
Mean size of paddocks (ha)	1470	873
Size range of paddocks (ha)	91–5299	40–4622
Area covered by large paddocks	156,424 ha (82.5%)	122,048 ha (64.4%)

3.5. A National Park and its grassland ecological condition

The grassland ecological condition was measured in 101 paddocks covering 1452 km² (Fig. 1). This portion of the study area included lands selected for a national park and buffer area. Its original selection was based on the quality of the habitat, with only 9.1% (131.65 km²) of the area in exotic grasses prior to 1996 (Fig. 2).

The excellent ecological condition was not found within this park region because all paddocks had some

cattle impact. Regular ecological condition was the most common category, and covered 38.7% (561.87 km²) of the area in 1996 (Fig. 3). However, 310.2 km² (21.4%) were in very good ecological condition, and 340.61 km² (23.5%) were in good ecological condition. At the same time, a small area was in poor ecological condition (7.4%).

When the 2001 image is compared to the 1996 survey, all ecological conditions were affected by the habitat conversion. The replaced area rose from 9.1 to 51.1% (741.5 km²), with the remaining 48.9% (710.64 km²) as natural grassland. Replacement of natural grasslands

occurred regardless of their ecological condition. The areas considered very good or good categories in 1996 were reduced from 44.8 to 24.4%, while paddocks considered regular or poor were reduced from 46.1 to 24.5% (Fig. 3).

From the 1694.53 km² (37.8%) of natural grassland remaining in the study area in 2001, 75.5% are located within the abundant deer zone. Three patches of natural grassland greater than 993 km² remain in 2001 (Fig. 2). The proposed national park covers 11,500 ha (6.8% of the remaining grassland) of the northwest patch (Fig. 2). Linkages between the three grassland patches are evident on the image.

4. Discussion

Although many of the world's grasslands include mesic regions developed for arable farming, natural grasslands still persist in areas considered unsuitable for agriculture (Riveros, 1993). Land transformation to agriculture or ranching is perhaps the most important process affecting the extent of grassland systems (Hadley, 1993). Studies documenting landscape transformations have come mostly from forested areas that were converted to agriculture (Simpson et al., 1994; Wolter and White, 2002), and are generally lacking for grassland ecosystems (Joern and Keeler, 1995).

In the San Luis grassland, the reduction of the extent of natural grasslands from 84 to 38% during a 16-year period (1985–2001) is striking. This transformation rate was significantly higher than that reported for other regions of the Argentine pampa, where conversions from 1960–1985 eliminated 5–15% of the grasslands (Viglizzo et al., 2001). However, the more mesic grasslands within the pampa did experience comparable conversion rates in the early 1900s (Viglizzo et al., 2001). Coppedge et al. (2002) detected an overall landuse change of 10–12% from 1965 to 1995 in the northwestern Oklahoma grassland. As with our study area, during that period grasslands in Oklahoma were converted to forage grasses as part of a government program to enhance farm productivity. In both South and North American grasslands, natural and socio-economic factors affected the rate of habitat modifications.

Natural grasslands in San Luis Province have been used for cattle breeding for more than 100 years (Viglizzo et al., 2001). A significant percentage (84.5%) of natural grasslands persisted until 1985 because large undeveloped ranches conducted cattle breeding at very low cow densities, often less than 1 cow per 10 hectares. After 1985, changes in socio-economic factors had ramifications for the extent of natural grasslands in the San Luis Province. From 1985 to 1992 grassland replacement was due to different factors in eastern and wes-

tern sections. In the eastern portion of the study area, and throughout the more mesic Argentine pampa (Peña Zubiate et al., 1998), grassland replacement was due to ranch conversion from livestock to agriculture (Viglizzo et al., 2001). Although agriculture is risky in semiarid regions due to soil and climatic restrictions (Stafford Smith and Foran 1993), ranchers were encouraged to diversify and produce some crops in more productive and accessible regions. In the western portion of the study area, where precipitation was more scattered, overgrazing and incorrect management resulted in the replacement of palatable grass species by the least palatable species (Dyksterhuis, 1958; Aguilera et al., 1999a). A common response by the San Luis' ranchers was the replacement of less productive natural grassland areas by an African grass (*Eragrostis curvula*) that increase the ranch carrying capacity for livestock (Frasinelli, 1998). However, *E. curvula* is only a summer forage due to its low palatability during the winter (Covas and Cairnie, 1985; Fernandez et al., 1991). Consequently, the replacement of natural grassland by *E. curvula* rarely exceeded 15% of the total ranch area. This grazing system required large natural grassland areas to feed livestock during the winter (Marchi et al., 1974; Frasinelli, 1998).

The accelerated grassland conversion from 1992 to 1997 coincided with a regional cattle development plan applied by the provincial government (Plan de Desarrollo Ganadero para la Provincia de San Luis, 1994). Ranches that increased the numbers of cattle or facilities (e.g. pastures, fences) received a tax discount from the government. In conjunction with this, a more palatable African pasture grass was introduced (*Digitaria eriantha*) and many ranchers converted natural grassland to this new pasture type due to its apparent profitability. At the same time, large paddocks were subdivided to increase cattle carrying capacity through pasture rotation (Frasinelli, 1998).

Despite these modifications in ranching practices, a high percentage of natural grassland remained in the proposed national park and buffer area prior to 1996 (Fig. 2). However, a 1996 proposal to create a national park in the area had negative consequences, as some ranchers accelerated their conversion of natural grasslands into exotic grasses to avoid possible purchase by the national government (Fundación Vida Silvestre Argentina, 2000).

Natural grasslands in very good and good ecological condition have the greatest livestock profitability (Molinero et al., 1996). Because it is a new farming practice to the region, the sustainability of converting pastures to *D. eriantha* is still under study (Frasinelli et al., 1992), with potential problems due to competition from weedy species (Aguilera et al., 1999b). Official recommendations are that only natural grasslands in poor ecological condition and low carrying capacity

should be replaced with *D. eriantha* (Aguilera et al., 1998, 1999a, b). However, our data indicate high quality natural grasslands (i.e. those in very good and good condition) were reduced from 45 to 20% in the region since 1996. The rancher's desire to maintain short-term profitability, plus their resistance to being included in the proposed national park, probably led to the rapid replacement of the natural grasslands. Despite the provincial plan to protect pampas deer natural habitat, the lack of a coherent government policy facilitated the opposition of the local ranchers and the accelerated loss of deer habitat.

Although there is no direct evidence that natural grasslands are essential for pampas deer survival, many authors suggested that land use intensification affects negatively the presence and abundance of pampas deer. Dellafiore et al. (2001) observed that the percentages of crop or exotic grassland areas, cow density, and internal ranch subdivision were negatively correlated to pampas deer density. Moore (2001), studying two populations of pampas deer in Uruguay, observed that the population confined with domestic cattle experienced high mortality (25–33%), possibly due to disease transmission from cattle. Bianchini and Perez (1972) speculated that the introduction of domestic cattle displaced pampas deer to sub-optimal habitats, thus contributing to its extinction. Jackson and Giulietti (1988) observed that cattle and pampas deer diets have significant overlap, and the two species could compete for food resources. In San Luis, two newly paved roads are being added to the western portion of the study area to facilitate cattle production. Tomás et al. (2001) observed that pampas deer in Brazil avoided areas with roads. Increased intensify of land use in the semiarid pampas could precipitate deer extinction through competition with livestock, increased human activity, such as poaching and road construction, and deer exclusion to non-palatable areas.

The conversion of natural grassland in San Luis is probably an irrevocable modification of the landscape. In a previous study, Aguilera et al. (1998) found no significant recovery of the dominant perennial species with decreased grazing pressure. These grass species were also not able to recolonize sites where crop cultivation was abandoned (Aguilera et al., 1998). Significant disturbance to this xeric grassland seems to generate a set of discrete vegetative states that do not result in the grassland returning to its original state (Anderson et al., 1970; Aguilera et al., 1998). Natural grassland restoration through the seeding of the dominant species might be a possibility. Suitable seed drills, have been developed, but they had not been completely tested (Aguilera, personal communication). On the other hand, the domestication of *Poa ligularis*, one of the most important palatable species of the San Luis natural grassland, was abandoned due to technological

difficulties and economic cost (Terentti et al., 1987). Given the large area affected, and the current economical situation in Argentina, we see limited opportunities for restoration.

Despite the conversion of natural grasslands occurring in the last 16 years, 1279 km² of natural grassland still persist in the western area where pampas deer are abundant. Some of this grassland will come under government management (20.4% of the national park and buffer area), and will have an important significance for the conservation of the Argentine Pampa region. In 1996, the best potential area for a national park was selected, based on current pampas deer distribution and natural grassland ecological condition (Demaría et al., 1996). However, due to the grassland replacement that has occurred between 1997 and 2001 we recommend a westward shift in the park's boundaries based on present grassland quality, deer distribution, and possibilities of land acquisition.

At its present size and location, a large portion of natural grassland still would be outside the park's boundaries, and an important number of deer would not be protected. Therefore, a management plan that considers the use of corridors and affects the entire natural grassland area should be implemented to halt grassland conversion and destruction. Conserving pampas deer will take cooperation, not subversion, from local ranchers. There has been success in other grasslands incorporating local concerns into the conservation planning process (Western, 1989; Saberwal, 1996; Fernandez-Gimenez, 2002). Saberwal (1996) argues that exclusion of grazing livestock from protected areas is counterproductive because of the difficulties in controlling access, and regulation of grazing levels is a better approach to conservation. Regulating stocking levels and grassland conversion may be more productive than attempts to increase the number of protected areas within the Pampa. Other authors have advocated including wildlife status and landscape integrity as criteria for ranchland sustainability in the Argentine Pampa (Ghersa et al., 2002). A comprehensive conservation plan for the San Luis Province persists as the decisive challenge for pampas deer survival, and is probably the last possibility for natural grassland conservation in Argentina.

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