Effects of 20 years of parceling on the condition of communal rangeland on a Mexican ejido

Efectos de 20 años de la parcelación sobre la condición del agostadero comunal de un ejido mexicano

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Abstract

This study evaluated the current condition of rangeland on 18 out of 62 plots created in 1993 by parceling the communal rangeland of the El Castañón *ejido* (Catorce, San Luis Potosí, México). Six plots located in three different rangeland sites were analyzed: two, visually characterized as 'good', two as 'poor', and two as 'intermediate'. The density and volumetric biomass of the preponderant perennial species were estimated after grouping them by vital form and forage value. The current state of soil cover was assessed using Canfield's line intercept method. Estimates of the variables of vegetation structure and soil cover on the plots were then subjected to multivariate analysis (DECORANA). The hypothesis established that the concepts of site and condition of rangeland, developed for climatic grasslands in the USA, are valid for multi-stratified rangelands in the scrublands of the potosino highland. The three sites of rangeland and the visual assessments of their condition were confirmed by the results of the analyses of vegetation and soil cover. After prioritizing 17 characteristics of the 18 plots, we confirmed that the variables density and biomass by groups of species with distinct forage value, and the ratio of bare soil to ground covered with vegetation and mulch, generated adequate evaluations of the condition of these rangelands. The studied plots showed important differences in rangeland condition, after 20 years of parceling and individual exploitation.

Keywords
Multi-stratified rangelands • rangeland site • multivariate analysis • desertization

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Resumen

Se evaluó la condición de agostadero actual en 18 parcelas de las 62 creadas con la parcelación en 1993 de los agostaderos comunales del ejido El Castañón (Catorce, San Luis Potosí, México). En tres sitios de agostadero se estudiaron seis parcelas, dos con cada condición visual de agostadero, buena, pobre e intermedia. Se estimó la densidad y biomasa volumétrica de las especies perennes preponderantes agrupadas por forma vital y valor forrajero. El estado actual de la cobertura del suelo se evaluó con líneas de intercepción de Canfield. Las estimaciones de las variables estructurales de vegetación y de la cobertura actual del suelo de las parcelas, fueron objeto de ordenación multivariable (DECORANA). La hipótesis establecida fue que los conceptos de sitio y condición de agostadero desarrollados para zacatales climácicos en EE. UU., son válidos en agostaderos multiestratificados de los matorrales del altiplano potosino. Los tres sitios de agostadero y la condición apreciada visualmente fueron confirmados con los resultados del levantamiento de la vegetación y de la cobertura actual del suelo. Se constató que las variables densidad y biomasa por grupos de especies con diferente valor forrajero, y las de proporción de suelo desnudo y cubierto con vegetación y mantillo, permiten evaluar adecuadamente la condición de este tipo de agostaderos. Las parcelas evaluadas presentaron diferencias importantes en la condición de agostadero, después de 20 años de la parcelación y aprovechamiento individual.

Palabras clave

Agostaderos multiestratificados • sitio de agostadero • análisis multivariable • desertización

Introduction

With the exception of areas covered by humid forests, cultivation, bare soil, rock, ice, concrete and deserts, most of the rest of terrestrial cover can be classified as rangeland, including scrublands, sub-humid forests, and all types of natural grasslands. Due to physical limitations, rangelands are areas with low productivity. However, and even though they are unsuitable for cultivation, they can produce livestock and wildlife with persistence (13, 14, 16, 17). Worldwide, over 50% of the terrestrial surface is used as rangeland (17). Interestingly, this ratio is repeated in Mexico and in the state of San Luis Potosí. Although rangelands, under rational management, remain productive and environmentally stable for undefined periods, growing abuse of rangeland on the highland of San Luis Potosí is evident, and cattle mortality during droughts provides the only opportunity for these zones to recover. Consequently, such widespread unconscious process of desertification causes the organic production potential of these lands, to gradually and irreversibly shrink (24). There are three modalities of land tenure in Mexico: private property, *ejidal* usufruct and communal usufruct. The latter two, corresponding to the so-called social population sector, have been administered by the State (12). Under social tenure, cattle from usufruct rights, feed on forage of communal lands.

Generally speaking, the limit on the number of animals that people with these rights can graze, is how many they can accumulate (6, 8). The fact that Agrarian Law has no rules for the exploitation of such lands has generated one of Mexico's main environmental problems; namely, the severe and generalized over-exploitation of communal rangeland, which causes desertification, acute reduction in animal productivity, and the growing migration of people from ejidos (8). The El Castañón y Anexos ejido was established on February 13th, 1946, with a first dotation of lands (9,300 ha). In 1993, the *ejidatarios* performed a preliminary repartition during which they measured the whole area and allowed *ejidatarios* to sub-divide and fence individual plots (J. Coronado, pers. comm.). On September 17th, 1996, the Ejidal Assembly ratified the delimitation, beneficiaries, assignations and certification of rights to those plots. At that time, there were 62 ejidatarios and nine 'postulants', and the National Agrarian Registry (RAN) (27), defined 13,514.21 ha as lands destined for common use. Those areas were omitted from the assignation and deeding of house lots and fields for run-off cultivation (27). In 2000, the ejidatarios hired a private firm to measure the plots with higher precision and elaborate an internal map of the ejido. That document was registered with the RAN, which could then issue deeds titles of private property. In that way, individual 222 ha lots were delimited and assigned. This is the only ejido on the state that, to date, has taken advantage of the reforms to Article 27 of Mexico's Constitution stating that sharing out permits the common use lands and giving individual title. This case is particularly interesting because the ejidatarios parceled the rangeland despite government reluctance and the lack of official support. Hence, an endogenous initiative that allowed individual ejidatarios to decide what to do with, or how to exploit, their resources is here being examined (24). The rational and persistent use of spontaneous vegetation to raise livestock, still requires considering the concepts of site potential, condition and tendency developed in the first half of the 20th century (28). A rangeland site is distinguished by a certain potential for sustained animal production resulting from the combination of environmental biotic and abiotic factors and the natural disturbance regimes, which together determine the characteristics of primary production (3, 23, 31). The classic concept of condition posited by Dyksterhuis (1949) refers to the current state of the plant community with respect to the climax vegetation characteristic of the site. Humphrey (1949), in contrast, related rangeland condition to real forage production *versus* the amount that the site is capable of producing. For each rangeland site to establish differences in the state of the vegetation and soil surface that result by grazing is possible. The series of relatively-discrete differences, is called 'rangeland condition', and the different categories of condition tend to be named in relation to the one that would be optimal for the site: 'poor', 'regular', 'good' or 'excellent' (10, 17, 21, 23). 'Tendency', finally, refers to the direction or trajectory of the condition. Tendency may be progressive, regressive, stable or divergent (3, 23, 31). These concepts are not widely known or applied in Mexico (3). To evaluate condition, the plants are usually grouped in desirables, less-desirables, and undesirables, according to their reaction to grazing (15, 17, 23, 25, 29, 32, 33). The postulated hypothesis stated that the concepts of site and rangeland condition developed for climatic grasslands of North America, are also valid for multi-stratified rangelands (scrubs) in the potosino highland. The objectives were to identify and characterize existing range sites and to evaluate their current condition by analyzing a sample of plots on the Castañón ejido, after 20 years of individual management. To achieve these objectives, measures of vegetation and soil surface were gathered on 18 parcels located in the three tentative rangeland sites recognized along the previous gradient of general deterioration, and with visual assessment of three classes of apparent condition: good, regular and poor.

Materials and methods

Study area

The El Castañón y Anexos ejido is located northeast of the municipality of Catorce in the state of San Luis Potosí, Mexico. Its surface area is almost 15,000 ha (figure 1). Physiographically, it is on the Northern Mexican Highplain (30). According to the Instituto Nacional de Estadística y Geografía de México (INEGI) thematic maps (2001), its geological substrate consists of tertiary

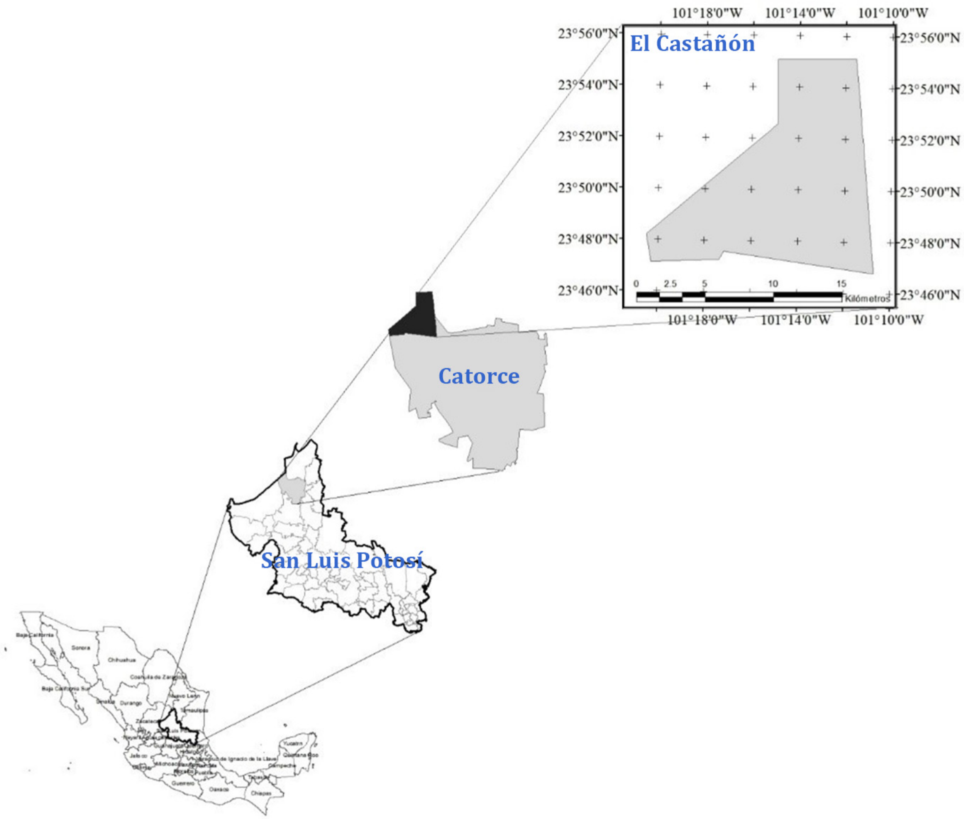

Figure 1. Geographic location of the Castañón y Anexos ejido.

Figura 1. Localización geográfica del ejido El Castañón y Anexos.

and quaternary conglomerates, while its drainage system connects to the hydrological region called El Salado. Its subterranean hydrology presents units of medium permeability with compounds of unconsolidated material. The ejido's climate is classified as $BS_0kw''(e)$; that is, dry temperate with mean annual temperature of 12-18°C, mean temperature in the coldest month of -3 to 18° C, summer rains, winter precipitation above 10.2%, and hot summers. Mean annual precipitation (at the *Santa María del Refugio* weather station) for the 1951-2010 period was 300.1 mm (5). The predominant soil is calcisol, but there are units of leptosol and phaeozem (19). The main types of vegetation present are Micro leaf Desert Scrubland and, in a lower proportion, Rossette leaf Desert Scrubland (figure 2, page 194) (19). The most important human settlements are Charco Largo and Castañón, located at 101°12' W and 23°51' N at 1,920 m a. s. l., and at 101°16' W and 23°49' N, at 1,994 m a. s. l., respectively.

Physiognomic classification of vegetation

A SPOT satellite image taken in February 2013 allowed the recognition –unsupervised– in ARC GIS v. 2010, of five visual classes or patterns, corresponding to the distinct types of soil cover on the ejido (figure 2, page 194). Later, these classes were directly confirmed, leading to discard the Rossette leaf Desert Scrubland given that it is located in hilly areas, inaccessible to bovines given its steep gradients. Other discarded zones were the ones occupied by cultivated fields, some highly-degraded areas with rocky subsoil and no vegetation, and roads. The remaining three classes of cover where grazing takes place, included two variants of Micro leaf Desert Scrubland, with several arborescent plants, principally *Yucca filifera* Chabaud (MDSMAP), another with few arborescent plants (MDSFAP), and the ecotone between Micro leaf Desert Scrubland and Rossette leaf Desert Scrubland (MDS-RDS). Herbarium specimens of the perennial species from each of the three variants of cover considered as rangeland, were collected. Annual herbaceous plants were not included because they are of little significance for livestock production or for evaluating condition in these rangeland types. The specimens gathered were identified and then deposited in the *herbarium Isidro Palacios* (SLPM) of the *Instituto de Investigación de Zonas Desérticas,* UASLP.

Structural measurements of vegetation

Based on field visits, the INEGI's thematic maps, and the classification map of the unsupervised cover, the rangeland condition of 18 of the 62 existing livestock-grazing parcels on the ejido was visually-recognized as good, regular and poor (figure 2, page 194). All data are presented as means of the two plots from each site and condition. Next, the technique developed by Cottam and Curtis (1956), with the adjustments applied by Aldrete and Aguirre (1982) for multi-stratified vegetation and the use of absolute values, was employed to estimate density (individual ha^{-1}) and instantaneous volumetric biomass ($m^3\ ha^{-1}$) for the individual perennial species detected on the sample plots. Transects were drawn with a 100-m-long nylon cord, tensed with steel stakes and marked at 1-m intervals and every 5 and 25 m to facilitate surveying. The transects were placed at least 50 m from fence lines in the most representative vegetation area of each plot, perpendicular to the slope.

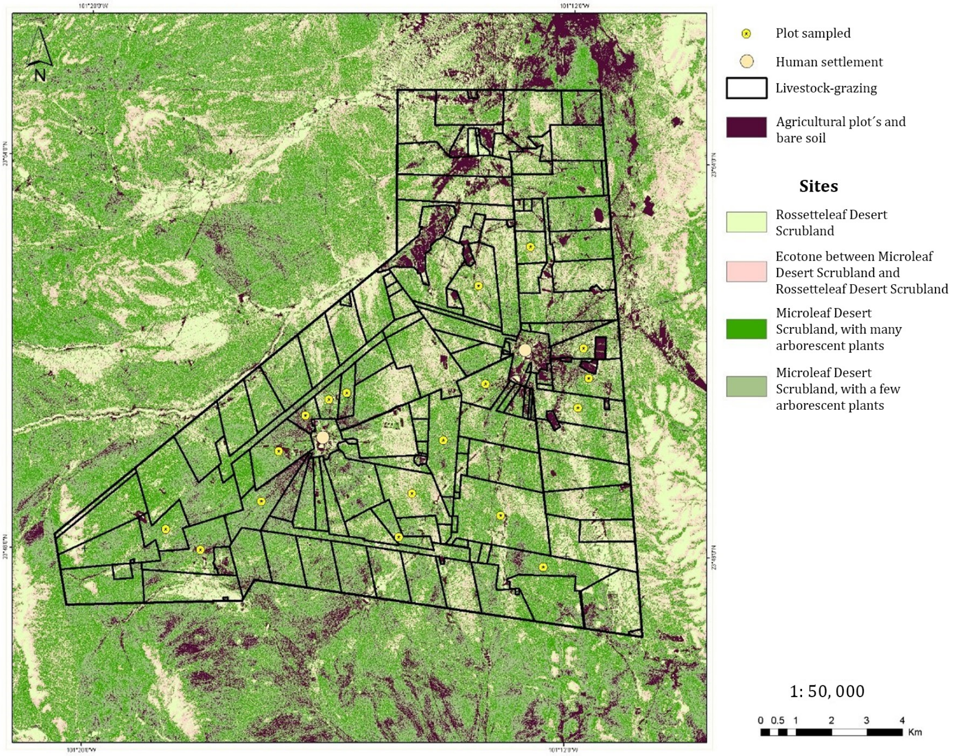

Figure 2. Parceling of communal rangeland on the El Castañón y Anexos ejido. Sites and plots sampled.

Figura 2. Parcelación del agostadero comunal del ejido El Castañón y Anexos, sitios de agostadero y parcelas muestreadas.

The initial and final points of each transect were geo-referenced and then, at every 10 m a 10-m cord was perpendicularly installed to form the four quadrants. Before measuring, each transect was inspected in its entirety and all the perennial plant species present inside were listed. Those plants were then grouped in four strata according to their vital form, as follows: herbs, low shrubs, tall shrubs, and arborescent plants. After sampling, this list was completed by adding the other perennial species present in the plot, but without registering them in the samples. This procedure allowed a compilation of an almost complete botanical list for each plot. Following Cottam and Curtis (1956), the distance from the point to the foot of the closest plant in each stratum was measured, recording its species, basal diameter, top diameter and height. First, the individuals of the herbaceous stratum were measured, as they were the densest and those most susceptible to suffering harm by trampling. Then the other strata were measured until each point was completed. When an individual plant was the one closest to two points, the second point was shifted 10 m. If upon terminating the survey of a 100-m transect, fewer than 10-12 recordings were made for one or more of the most important species, that transect was extended, or a parallel one established, in order to increase the number of points until completing the required recordings and concluding the sample. The species of plants recorded in the sample were then classified as desirable, less-desirable or undesirable according to their forage value and successional reaction to grazing, following Valentine (1982) and Bolaños and Aguirre (2000). To calculate each species' density, the reciprocal of the square of the mean distance of each species (*i.e.*, the mean area of each species), was used. The aerial and instantaneous volumetric biomass of each individual, was calculated by the following truncated cone formula:

$$V= 1/3\pi h\ (R^2+r^2+Rr)$$

where:
π= 3.1416
h= height between the two radii
R= radius of the top or expansion
r= basal radius

State of soil surface

To estimate the state of soil surface on each plot, five Canfield intercept lines (4) were used, each one 5 m long, parallelly installed and alternate to the main transect. The beginning and end of each line were also geo-referenced. The intercepted portions of bare soil, soil with vegetation, mulch, rocks or feces were measured along these lines.

Range use patterns

Between December 2013 and January 2014, a survey to 41 ejidatarios was applied. These ejidatarios were responsible for 58 of the 62 plots produced by the parceling of the ejido's communal rangeland in 1993. The aim was to determine the effects of 20 years of individual exploitation (24). Based on this information and our estimates of the attributes of the vegetation and soil surface of the 18 plots studied, an 18 x 17 data matrix was elaborated and processed using the multivariate analysis program PC-ORD v. 6 (2011), specifically with the DECORANA module to perform ordering.

Results and discussion

Floristic composition

A total of 221 sampling points were established in the 18 plots, equivalent to 884 quadrants, and 2,210 individuals of plant species were measured. In some plots, the minimum number of recordings (10-12) established for the most important species was reached in seven points of the transects, though in others as many as 13 points, were necessary. For this reason, estimates of biomass and absolute density of each species, were analyzed according to the respective number of recordings. After sampling all plots, 27 perennial species were identified and measured. From the 27, 12 were herbaceous, 9 were low shrubs, 3 tall shrubs, and 3 arborescent plants (table 1, page 196).

28 perennial species that fell outside the samples were also gathered: 12 herbaceous, 12 low shrub, 3 tall shrub, and 1 arborescent plant. Thus, the total number of perennial floristic species in the plots analyzed was 55, 30% higher than the 38 species registered by Pinos *et al.* (2013) in San José de la Peña, Villa de Guadalupe, San Luis Potosí, Mexico, on communal rangeland exploited primarily by goats. This result is also higher by 57% and 150%, respectively, than the perennial

Table 1. Perennial species registered in the samples from plots on the El Castañón ejido.
Tabla 1. Especies perennes registradas con el muestreo en parcelas del ejido El Castañón.

Species	Vital form*					Site¶
	H	LS	TS	AP	FV†	
Acacia schaffneri (S. Watson) F.J. Herm.				x	2	3
Bouteloua gracilis (Willd. ex Kunth) Lag. Ex Griffiths	x				1	1,3
Bouteloua karwinskii Griffiths	x				1	2,3
Condalia mexicana Schltdl.			x		3	1,2.3
Cylindropuntia imbricata (Haw.) F.M. Knuth			x		3	1,2,3
Cylindropuntia leptocaulis De Candolle			x		3	2,3
Dasyochloa pulchella (Kunth) Willd. ex Rydb.	x				2	1,2,3
Echinocereus pentalophus (DC.) Lem.		x			2	1,2,3
Erioneuron avenaceum (Kunth) Tateoka	x				1	1
Flourensia cernua DC.			x		3	1,2,3
Gymnosperma glutinosum (Spreng.) Less.	x				2	2
Jatropha dioica Sessé ex Cerv.		x			3	1,3
Larrea tridentata (Sessé & Moc. ex DC.) Cov.			x		3	1,2,3
Mimosa biuncifera Benth		x			3	1,3
Muhlenbergia villiflora Hitchc.	x				1	1
Nassella leucotricha (Trin. & Rupr.) R. W. Pohl	x				1	1
Opuntia cantabrigiensis Lynch			x		2	1,2,3
Opuntia rastrera F.A.C.Weber		x			2	1,2,3
Parthenium argentatum A.Gray		x			1	1
Parthenium incanum Kunth		x			1	1,2,3
Prosopis laevigata (Willd.) M.C. Johnst.				x	2	1,2,3
Setaria macrostachya Kunth	x				1	1
Sporobolus airoides (Torrey) Torrey	x				1	1,2,3
Thymophylla pentachaeta (DC.) Robinson	x				2	1,2,3
Yucca filifera Chabaud				x	2	1,3
Zinnia acerosa (DC.) A.Gray	x				2	1
Zornia thymifolia Kunth	x				2	2

† Forage value: 1=Desirable; 2=Less-desirable; 3= Undesirable. ¶ Site: 1= MDS-RDS; 2= MSDFAP; 3= MDSMAP. *H: herbaceous; LS: low shrub; TS: tall shrub; AP: arborescent plants.

† Valor forrajero: 1=Deseable; 2=Menos deseable; 3=Indeseable. ¶ Sitio: 1= MDM-MDR; 2= MDMPPA; 3=MDMMPA. *H: herbácea; AI: arbustiva inferior; AS: arbustiva superior; PA: plantas arborescentes.

species recorded at three rangeland sites on a cattle ranch (with rangelands in better condition) and a neighboring ejido (with worse rangelands) in Charcas, San Luis Potosí (20). On the other hand, they were less than the 96 species registered in Borana rangelands, in southern Ethiopia (2), although in that study the total number of species was considered.

Differences among the rangeland sites

The physiognomic differentiation of the sites based on satellite images was confirmed by the distinct botanical composition of the main species (table 1, page 196) and, especially, by the differences in the predominant desirable species: *B. karwinskii* and *S. airoides* at MDSFAP and MDSMAP sites, and *B. gracilis* and *S. airoides* at RSD site. In addition, when comparing only the plots in good condition at the three sites avoiding the effects of overgrazing on the structure, the MDS-RSD and MDSMAP plots presented only 76.80% and 88.47% of the total density registered in the MDSFAP plots, respectively (table 2). Regarding biomass, the structural differences among sites in good condition were greater. Only 40.50% and 57.24% of the total estimated biomass for MDS-RDS, were registered for MDSFAP and MDSMAP respectively, (table 3, page 198). These differences in the vegetation structure of the sites may also be related to soil heterogeneity, as recognized in the corresponding edaphological card (19).

Table 2. Effect of the visual condition of range on density (individuals ha^{-1}), according to rangeland site and forage value of the species.

Tabla 2. Efecto de la condición visual de agostadero sobre la densidad (individuos ha^{-1}) de acuerdo con el sitio de agostadero y valor forrajero de las especies.

Visual condition of rangeland						
Site	**Good**		**Regular**		**Poor**	
Forage value	**Absolute**	**Relative**	**Absolute**	**Relative**	**Absolute**	**Relative**
MDSMAP						
Desirable	76,209	93.6	24,783	85.9	11,527	52.8
Less desirable	2,485	3.1	676	2.3	3,201	14.7
Undesirable	2,674	3.3	3,390	11.8	7,082	32.5
*Total**	81,368	100.0	28,849	100.0	21,810	100.0
MDSFAP						
Desirable	103,607	97.8	6,852	53.9	3,869	50.5
Less desirable	217	0.2	3,867	29.8	1,304	17.0
Undesirable	2,111	2.0	2,119	16.3	2,488	32.5
*Total**	105,935	100.0	12,838	100.0	7,661	100.0
MDS-RDS						
Desirable	85,215	90.9	21,260	65.7	8,867	51.0
Less desirable	4,177	4.5	8,533	26.4	4,853	27.9
Undesirable	4,334	4.6	2,555	7.9	3,658	21.0
*Total**	93,726	100.0	32,347	100.0	17,378	100.0

*n=6

Hence, MDSMAP was located principally in zones with calcisol, MDSFAP was associated with calcisol and leptosol, while the ecotone in MDS-RDS was located in a transition zone between calcisol and phaeozem. The identification of our rangeland sites using satellite images, partially coincides with what was done in Patagonia (11), in a study in which 7 kinds of vegetation cover were found, through an unsupervised classification process with high-resolution images. This study concluded that in order to continue their investigations, to include the respective field studies was necessary something already carried out in the present study.

Structural differences among plots at the same site due to exploitation pattern (condition)

Visual differences in plant cover among plots at the same site, attributed to degraded conditions, were clearly confirmed by the steadily decreasing tendency of total density (table 2, page 197) and biomass (table 3) at the three sites. The density of desirable species, markedly and consistently decreased with the worsening condition at the three sites, according to what has been described as a general tendency for species with greater forage value (9, 15, 17, 25, 28, 29, 32).

Table 3. Effect of the visual condition of range on volumetric biomass (m^3 ha^{-1}) according to rangeland site and forage value of the species.

Tabla 3. Efecto de la condición visual de agostadero sobre la biomasa volumétrica (m^3 ha^{-1}) de acuerdo con el sitio de agostadero y valor forrajero de las especies.

Visual condition of range						
Site	**Good**		**Regular**		**Poor**	
Forage value	**Absolute**	**Relative**	**Absolute**	**Relative**	**Absolute**	**Relative**
MDSMAP						
Desirable	1,040	14.1	1,339	45.1	628	31.0
Less desirable	5,482	74.4	147	4.9	142	7.0
Undesirable	850	11.5	1,484	50.0	1,258	62.0
Total*	7,372	100.0	2,969	100.0	2,028	100.0
MDSFAP						
Desirable	2,157	41.3	953	32.9	189	13.0
Less desirable	1,075	20.6	759	26.2	37	2.5
Undesirable	1,996	38.2	1,185	40.9	1,225	84.5
Total*	5,228	100.0	2,897	100.0	1,450	100.0
MDS-RDS						
Desirable	8,229	63.9	491	10.2	416	12.0
Less desirable	1,902	14.8	2,835	59.0	1,421	41.0
Undesirable	2,748	21.3	1,477	30.7	1,628	47.0
Total*	12,879	100.0	4,803	100.0	3,465	100.0

*n=6

In contrast to our findings for density, the reduction of volumetric biomass in the group of desirable species associated with the degradation of condition, was only very evident and consistent at MDSFAP and MDS-RDS sites, since at MDSMAP site, the most marked decrease was registered for the group of less-desirable species (table 3, page 198). Total volumetric biomass on the plots in good condition seems to be an adequate indicator of the differences in potential among the three sites on the El Castañón ejido. At the same time, total volumetric biomass diminished in general as the condition of the rangeland worsened. Density and biomass of the plots of the El Castañón ejido in good condition, with respect to that recorded both in a private ranch and a neighboring ejido (20), indicated the benefit of the parceling process, and the decision of their owners to decrease the stocking rate and establish slight to moderate grazing intensity.

On the other hand, the percentage of biomass produced by the undesirable species, in plots in poor condition for both studies (20) is similar, meaning that by itself, the parceling process does not impact on improving the condition, while there is no intention of balancing stocking rate with carrying capacity.

Soil cover

From the evaluated soil surface attributes, the area of bare soil and the area occupied by vegetation presented the most regular tendencies and best relations with the visually-appreciated condition: increasing bare soil and decreasing vegetation in the good, regular and poor conditions, at the three sites. These findings agree with those registered by Lara *et al.* (2016) and Contreras *et al.* (2003). The values for mulch also presented a downwards tendency as condition worsened, but this was less evident than for the aforementioned attributes. This indicates that the methodology applied was suitable for evaluating the state of health or condition of multi-stratified, multi-specific rangeland sites, which are much more complex than grasslands, in concordance with similar antecedents (1, 3, 20) (table 4, page 200).

Multivariate analysis of the evaluated attributes

The information on the current state of the vegetation and soil surface gathered in this sample of plots, as well as some variables linked to the individual form of exploitation (24), were computerized in a matrix and exported to PC_ORD v. 6.0 software (22) for multivariate processing using DECORANA (detrended correspondence analysis). According to the respective proper or characteristic value, only the first two axes of the ordering gathered information that was significant for interpretation. Thus, on the first axis of ordering (figure 3, page 201) a primary gradient for condition can be recognized, which runs from good-to-regular. Is important to point out, on the extreme left, the ordering of density and biomass for the group of desirable species (DENSDESE, BIOMDESE) and the ratio of soil surface occupied by mulch and vegetation (SUELMANT and SUELVEGE). These are the four attributes clearly related to a healthier state of rangeland, which is also favored by the higher number of divisions or fields in the plot (NUMPOTR), and by being located far from the town (DISTPOBL), meaning a lower residual effect of the deterioration priorto performing the parceling.

Table 4. Effect of site and visual condition of the range on mean soil surface cover (cm, %) (n=five 500 cm Canfield lines).

Tabla 4. Efecto del sitio y condición visual del agostadero sobre la cobertura media superficial del suelo (cm, %) (n=cinco líneas Canfield de 500 cm).

Visual condition of rangeland						
Site	**Good**		**Regular**		**Poor**	
Soil surface cover	**Absolute**	**Relative**	**Absolute**	**Relative**	**Absolute**	**Relative**
MDSMAP						
Bare soil	286.5	11.5	631.0	25.2	1,497.0	59.9
Mulch	830.0	33.2	1,019.5	40.8	477.5	19.1
Vegetation	1,159.0	46.3	789.5	31.6	525.5	21.0
Rocks	157.0	6.3	23.0	0.9	0.0	0.0
Feces	67.5	2.7	37.0	1.5	0.0	0.0
Total	2,500	100.0	2,500	100.0	2,500	100.0
MDSFAP						
Bare soil	256.0	10.2	1,516.0	60.6	1,696.0	67.8
Mulch	1,492.5	59.7	347.5	13.9	175.0	7.0
Vegetation	711.0	28.4	422.5	16.9	477.5	19.1
Rocks	37.0	1.5	199.0	8.0	151.5	6.1
Feces	3.5	0.1	15.0	0.6	0.0	0.0
Total	2,500	100.0	2,500	100.0	2,500	100.0
MDS-RDS						
Bare soil	27.5	1.1	1,501.0	60.1	1,522.5	60.9
Mulch	1,081.5	43.3	453.0	18.1	630.5	25.2
Vegetation	1,361.5	54.4	515.0	20.6	287.0	11.5
Rocks	20.5	0.8	31.0	1.2	39.0	1.6
Feces	9.0	0.4	0.0	0.0	21.0	0.8
Total	2,500	100.0	2,500	100.0	2,500	100.0

On the extreme right of the ordering bidimensional plot, the proportion of bare soil as a symptom of deterioration–either in progress or residual caused by the earlier period of parceling never remedied – stands out. This regression in condition is confirmed by the importance of the less-desirable or increasing species density, and by the causal agent, that is, the current stocking rate (CANTOTAL). Axis 2, meanwhile, corresponds to the gradient for regular-to-poor condition, where the variables density and biomass of the less-desirable species (DESMENO and BIOMMENO), and the scattered rocks exposed in the plot (SUELPIED) stand out in the lower area. The other extreme of the bidimensional plot (upper), highlights the density and biomass of the undesirable species (DENSINDE AND BIOMINDE) and the stocking rate at the beginning of parceling (BOVICOMI) as causes of the poor condition.

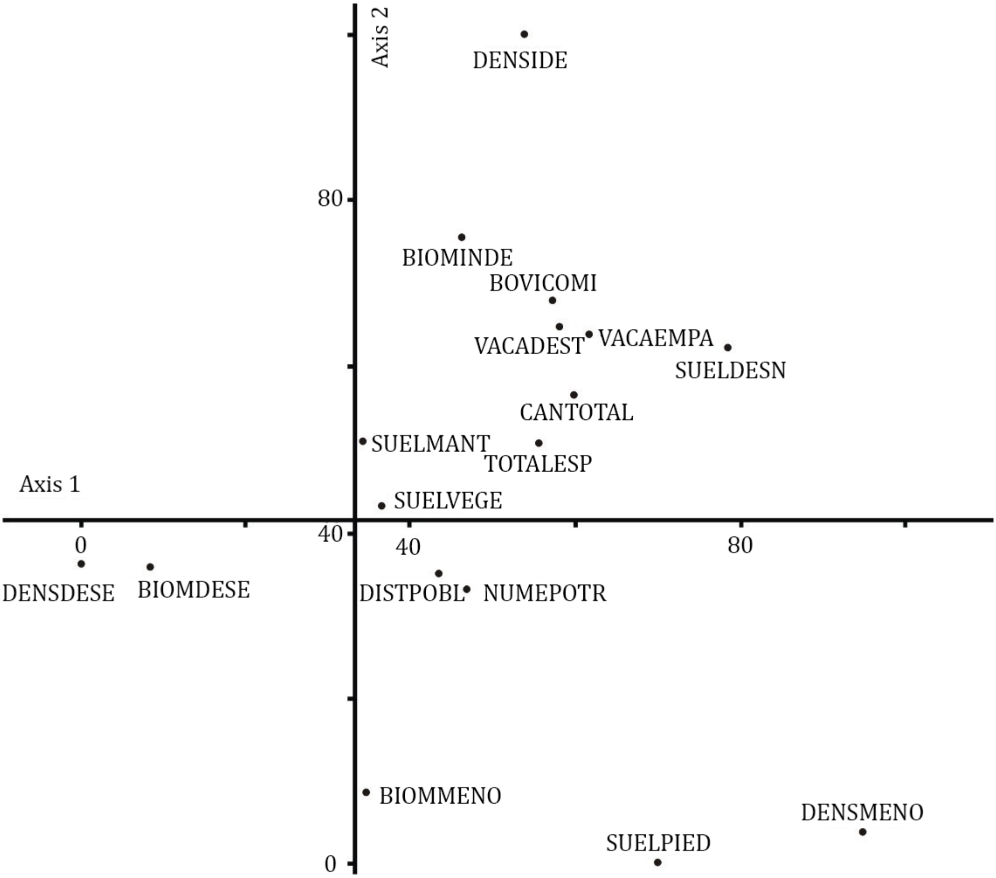

Figure 3. Ordering bidimensional plot of the variables evaluated the "El Castañón" ejido.

Figura 3. Ordenación bidimensional de las variables evaluadas en parcelas del ejido "El Castañón".

Conclusions

The structural surveys of vegetation confirmed the postulated distinction among three rangeland sites based on the satellite image. At these three sites, the visually-appreciated condition was confirmed by the total evaluations of weighted mean density and instantaneous volumetric biomass, both of which decreased as condition deteriorated. By the same token, the density and biomass values for the desirable species tended to decrease as condition worsened; a finding that resulted evident when density was assessed. The same tendency was registered for the current state of soil cover, since the mean percentages covered by vegetation and mulch stood out in the best condition while, in contrast, the proportion of bare soil increased as condition worsened.

The ordination of the attributes evaluated on the 18 plots made it possible to recognize and confirm, objectively, that the variables of vegetation structure and soil surface cover are the determinants of the three classes of condition.

Twenty years after parceling the ejido, individual plots present contrasting differences in the condition of their rangeland and, consequently, in their levels of production, due primarily to the independent decisions taken by their proprietors.

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