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Spatial organization of gneissic grasslands related to relief and soil variability

Organización espacial de pastizales gneísicos relacionada a la variabilidad del relieve y suelo

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1. INTRODUCTION

Structural aspects of the grassland landscape of the Córdoba Mountains (Central Argentina) having greater effects on regional variability, according to SOLNTSIEV (1974), MENGHI et al. (1989) and ACOSTA et al. (1989), are described. The study was centred in the analysis of geomorphological gradients mainly associated to different lithological substrates and altitudes.
Nomenclature follows CABRERA (1963, 1965a,b, 1967, 1968, 1970), BURKART (1974, 1979) and CORREA (1984a,b) .
The results showed that the continuity of the large scale gradients is often interrupted by local phenomena (herbivore pressure and edaphic variability, among others) which may be observed on increasingly detailed levels.
The gneissic substrate is the most extensive lithological support of the natural grassland belt of the "Sierras de Córdoba" mountains (VASQUEZ et al. 1979). At small scale, a typical gneiss slope presents a mosaic in which rocky outcrops alternate with deep soil zones ("biostasis") and with zones where the biogeoedaphic balance appears to be broken and erosion predominates ("rhexistasis"). The associated grassland presents a cellular structure varying in com-

position, plant cover and productivity (MENGHI 1987) as well as in its vulnerability towards anthropogenic impact.
It is supposed that the plant-relief-geomorphology complex corresponds to some edaphic properties predominant in the study area which would partly explain the variability observed in the grassland.
The present study focuses on the analysis of the local differences in plant structure, the underlying edaphic typology and the bioindicators of the spatial variation in the grassland of the gneissic environment.

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2. MATERIAL AND METHODS

2.1. STUDY AREA

The study was carried out in "El Cuadrado" at 31°S and 64°30W, in the altitudinal grassland belt (LUTI et al. 1979) (Fig. 1). The predominant vegetation in the "sub-piso inferior" consists of "pajonales" of *Festuca hyeronimi* (GALERA 1980).
The yearly mean temperature is 13°C and the mean rainfall 800 mm ranging from 500 to 1400 mm.
The most common land use is cattle grazing on native grasses with a periodical burn-off to control the unpalatable phytomass.
According to ZAMORA (1974) the gneissic landscape is abrupt with scarped (25-55%) and moderate (10-25%) slopes separated by deep valleys.
In the study area, the soil is derived from the gneiss alteration, and present general characteristics to regional scale (GORDILLO and LENCINAS 1979). The predominant soil is "lithic Usthorthent", sandy loam, with "metacuarcitas" and schists of fine grain almost intact within the zone of radical activity. The remaining components are alterated producing sand, clay and low percentages of silt.

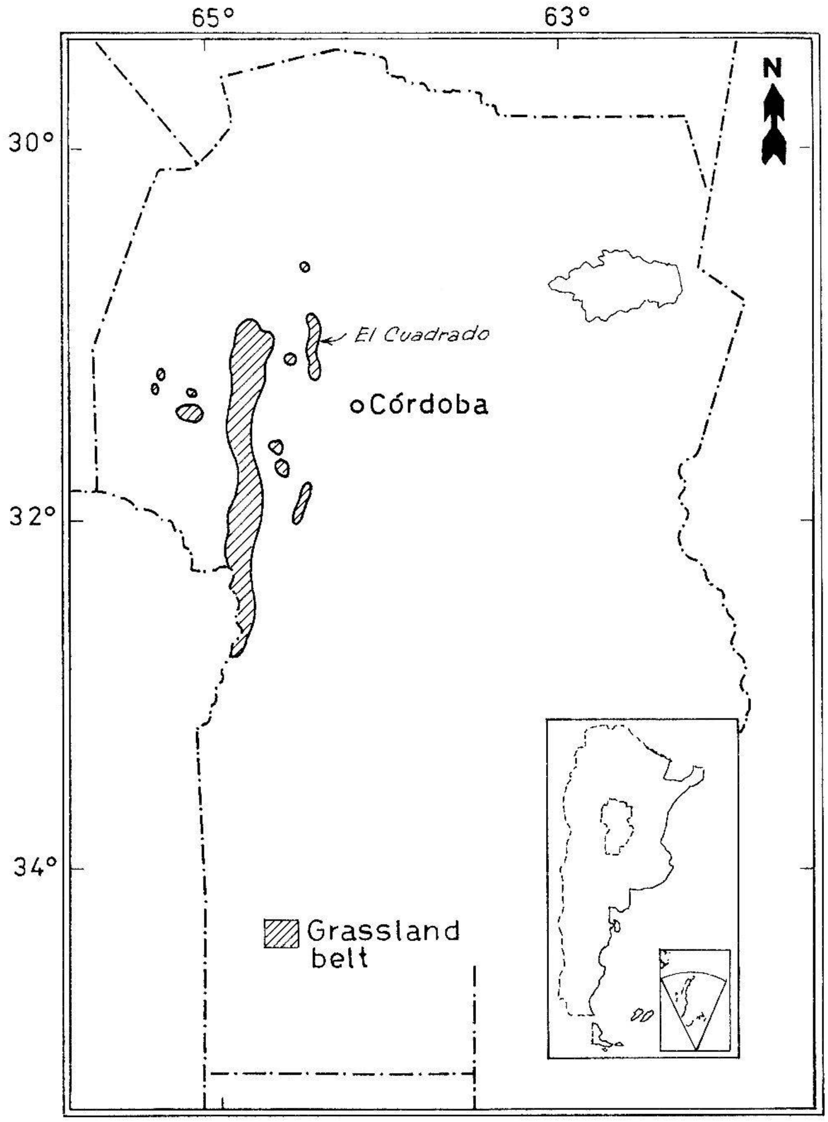

Fig. 1. Study area and montane grassland belt (LUTI et al. 1979).
Area de estudio y piso de pastizales serranos (LUTI et al. 1979).

On a more detailed scale, the substrate exhibits local heterogeneity, which is displayed directly in the relief as well as by the plant physiognomy.

A typical slope is short and convex, with divergent fluxes of water and material, presenting a mosaic of small patches with different grades of soil maturity. Rocky outcrops and residual soils alternate producing a recurrent mosaic pattern along the slope (Fig. 2).

The gneissic schists, easily fractured and mineralized, have surfaced in places or underlie the surface layer in small blocks at varying depths and inclina-

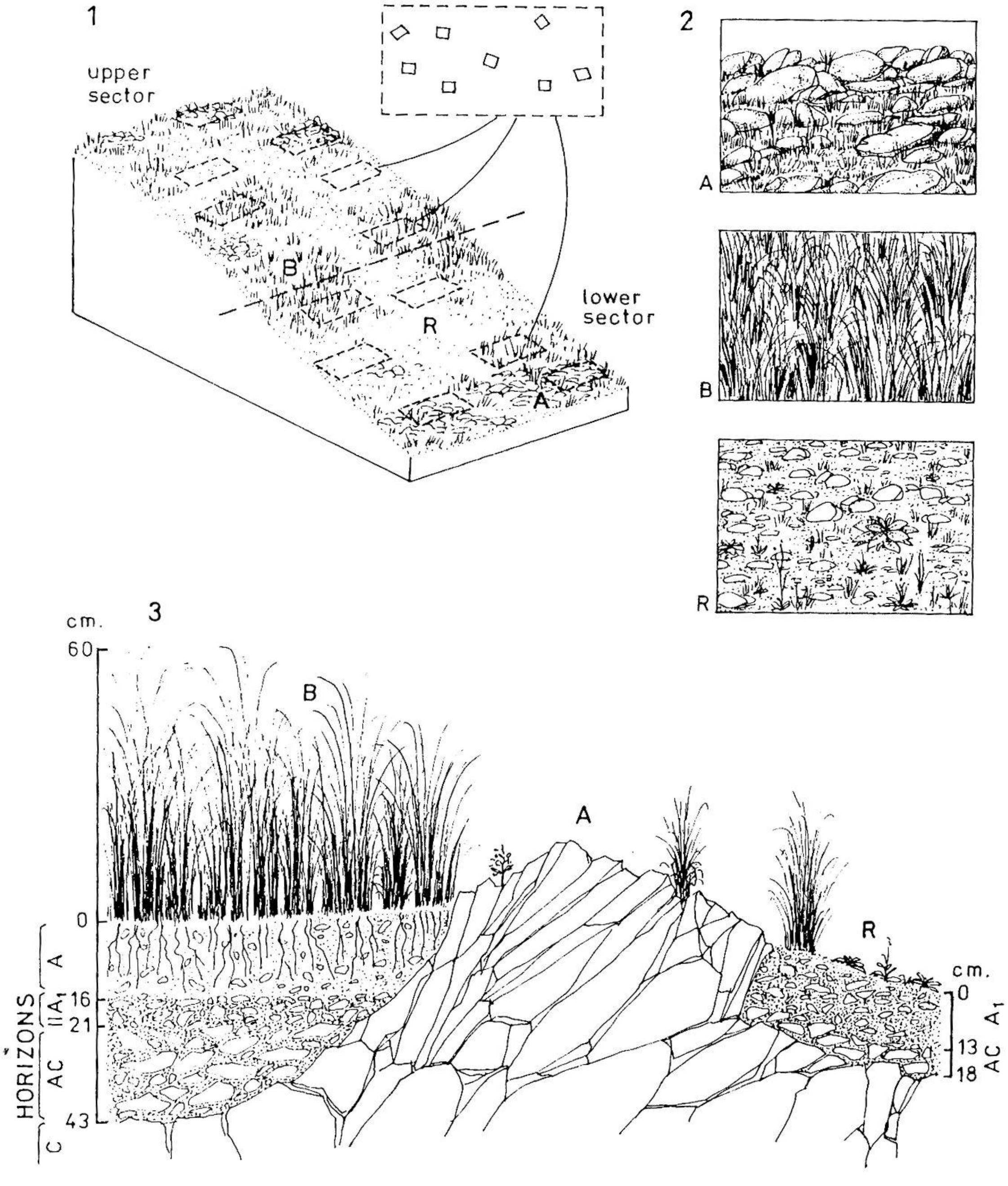

Fig. 2. Typical gneiss slope.

1. Geomorphologic sectors. Sample plot distribution in the upper and lower sectors of the slope.
   Sectores geomorfológicos de una ladera típica de gneis.
   Parcelas y cuadrados analizados en los sectores inferior y superior.
   A - rock outcrop - *zona con afloramiento*, B - biostasic zone - *zona en biostasia*, R - rexistasic zone - *zona en rexistasia.*
2. Detail of the analysed zones -*Detalle de las zonas analizadas.*
3. Diagrammatic representation of the predominant structure in plant and soil profile.
   Esquema de la estructura predominante en la vegetación y en el perfil edafico de las zonas analizadas.

tions. Thus, they are exposed in varying degrees to meteoric action and bio-edaphic development. The result is three ecological subsystems, characterized by the predominance of erosion or edifier processes, coexisting in the slope.
Each part of the mosaic was analysed in this study, resulting in the following general characteristics:

- Rocky outcrop: a mosaic in which big blocks and detritic cover alternate with accumulations of fine materials. There are sparse plant populations and isolated individuals (Fig. 2A).
- Biostasis: concave areas with converge fluxes of materials and water and edaphic development and dense plant cover of large tussock grasses (Fig. 2B).
- Rhexistasis: convex areas near the outcrops, with residual soils and divergent fluxes. The plant cover is low and sparse (Fig. 2R).

2.2. SAMPLING DESIGN AND DATA PROCESSING

The sampling site averaged 1000 m a.s.l. and was situated on three neighbouring slopes facing north. Overgrazed or recently burnt slopes were not sampled.
A stratified sampling was performed, considering an equal number of biostasis, rhexistasis and rocky outcrop zones in the upper and lower sectors of the slopes (Fig. 2). A 3x3 m sample plot was selected at each site. Within each plot the species were recorded in eight randomly located 20x20 cm squares.
Three slopes, six sectors, 36 parcels and 288 squares were examined. The list of the 106 recorded species is presented in Table 1.
The edaphic analysis was carried out on one slope in the same sectors and sampling plots in which vegetation was recorded. A soil profile was described and samples of the superior horizon were taken. The properties considered for laboratory analysis were granulometry (sand, clay, silt, coarse material), pH, organic matter (MO), resistance (Ω), cations (Na^+, K^+, Ca^{++}, Mg^{++}) and cationic interchange capacity (CIC).
The major trends in the spatial variation of plant species and soil properties were detected through multivariate analysis. Correspondence analysis (BENZECRI 1973) was applied to the data matrix of plant species, and principal components (HARMAN 1967) to data matric of soil variables.

Table 1. List of species - *lista de especies.*

Abbrev.	Species name	Family
ACC	*Acalypha communis* Muell.	*Euphorphiaceae*
ADC	*Adesmia corymbosa* Clos	*Fabaceae*
ALP	*Alternanthera pumila* Stutzer	*Amaranthaceae*
AMT	*Ambrosia tenuifolia* Spreng.	*Asteraceae*
HEL	*Aneimia tomentosa* (Sav.) Sw.	*Schizaeaceae*
APS	*Apium leptophyllum* (Pers.) F. Muell.	*Apiaceae*
ARA	*Aristida achalensis* Mez	*Poaceae*
ARP	*Aristida pallens* Cav.	*Poaceae*
ARS	*Aristida spegazzini* Arech.	*Poaceae*
BAR	*Baccharis rufescens* Spreng.	*Asteraceae*
BOE	*Borreria eryngioides* Cham. et Schlecht.	*Rubiaceae*
BOL	*Bothriochloa laguroides* (D.C.) Pilger	*Poaceae*
BOC	*Bouteloua curtipendula* (Michx.) Torr.	*Poaceae*
BOM	*Bouteloua megapotamica* (Spreng.) O.Ktze.	*Poaceae*
BRS	*Briza subaristata* Lam.	*Poaceae*
BUJ	*Bulbostylis juncoides* (Vahl) Kukenth.	*Cyperaceae*
CAS	*Carex* spp.	*Cyperaceae*
CEA	*Cerastium arvense* L.	*Caryophyllaceae*
CIV	*Cirsium vulgare* (Savi) Ten.	*Asteraceae*
COM	*Commelina virginica* L.	*Commelinaceae*
CRA	*Croton argentinus* Muell.	*Euphorbiaceae*
CYH	*Cynodon hirsutus* Sten.	*Poaceae*
CHI	*Chaptalia integerrima* (Vell.) Burkart	*Asteraceae*
CHS	*Chevreulia sarmentosa* (Pers.) Blake	*Asteraceae*
CHR	*Chloris retusa* Lagasca	*Poaceae*
DAP	*Daucus pusillus* Michx.	*Apiaceae*
DIH	*Dichondra sericea* Swartz	*Convolvulaceae*
DIR	*Dichondra microcalyx* (Hallier) Fabris	*Convolvulaceae*
DIC	*Digitaria californica* (Benth) Henrard	*Poaceae*
ELT	*Eleusine tristachya* (Lam.) Lam.	*Poaceae*
ERB	*Eragrostis bahiensis* Schrader	*Poaceae*
ERL	*Eragrostis lugens* Nees	*Poaceae*
ERN	*Eryngium nudicaule* Lam.	*Apiaceae*
EUS	*Euphorbia portulacoides* L.	*Euphorbiaceae*
EVA	*Evolvulus arizonicus* A. Gray	*Convolvulaceae*
EVS	*Evolvulus sericeus* Swart	*Convolvulaceae*
FAR	*Facelis retusa* (Lam.) Sch. Bip.	*Asteraceae*
FEH	*Festuca hieronymi* Haeckel	*Poaceae*
GAG	*Galactia glaucophylla* Harns	*Fabaceae*
GAM	*Galactia marginalis* Benth	*Fabaceae*
GAS	*Gamochaeta spicata* (D.C.) Cabrera	*Asteraceae*
GLD	*Glandularia dissecta* (Willd.) Schnack et Covas	*Verbenaceae*
GLP	*Glandularia peruviana* (L.) Small.	*Verbenaceae*
GNG	*Gnaphalium gaudichaudianum* D.C.	*Asteraceae*
GOP	*Gomphrena pulchella* Mart.	*Amaranthaceae*
GYS	*Gymnocalycium* sp.	*Cactaceae*
GYG	*Gymnopogon grandiflorum* Roseng., Arr. et Izag.	*Poaceae*
HYP	*Hybanthus parviflorus* (Mutis) Baillon	*Violaceae*
LEF	*Lepechinia floribunda* Epling	*Lamiaceae*
LEB	*Lepidium bonariense* L.	*Brassicaceae*
MAC	*Malvastrum coromandelianum* (L.) Garcke	*Malvaceae*
MAP	*Margiricarpus pinnatus* (Lam.) O.K.	*Rosaceae*
MII	*Microchloa indica* (L.f.) O. Ktze.	*Poaceae*

Table 1 (continued)

MIM	*Mitracarpus megapotamicus* (Spreng.) O. Ktze.	*Rubiaceae*
NIA	*Nierembergia aristata* Sweet	*Solanaceae*
NOC	*Nostoc commune* Vauchner	*Nostocaceae*
NOI	*Nothoscordum inodorum* (Ait.) Nicholson	*Liliaceae*
OEI	*Oenothera indecora* Camb.	*Onograceae*
OXS	*Oxalis sexenata* Sav.	*Oxalidaceae*
PAC	*Paronychia chilensis* D.C.	*Caryophyllaceae*
PAH	*Parthenium hysterophorus* L.	*Asteraceae*
PAD	*Paspalum dilatatum* Poiret	*Poaceae*
PAM	*Paspalum malacophyllum* Michx.	*Poaceae*
PAN	*Paspalum notatum* Fluegge	*Poaceae*
PAP	*Paspalum plicatulum* Michx.	*Poaceae*
PAA	*Pavonia aurigloba* Krap. et Crist.	*Malvaceae*
PFG	*Pfaffia gnaphalioides* (L.) Martius	*Amaranthaceae*
PIB	*Piptochaetium bicolor* (Vahl) Desv.	*Poaceae*
PID	*Piptochaetium medium* (Speg.) M.A.Torres	*Poaceae*
PIM	*Piptochaetium montevidense* (Sprengel) Parodi	*Poaceae*
PIS	*Piptochaetium stipoides* (Trin. et Rupr.) Haeckel	*Poaceae*
PLM	*Plantago australis* Lam.	*Plantaginaceae*
POL	*Poa ligularis* Nees.	*Poaceae*
POO	*Porophyllum obscurum* (Spreng.) D.C.	*Asteraceae*
POS	*Portulaca* sp.	*Portulacaceae*
RER	*Relbunium richardianum* (Gill. ex H.et A.) Hichken	*Rubiaceae*
RHM	*Rhynchosia minima* (L.) D.C.	*Fabaceae*
RHS	*Rhynchosia senna* H. et Arn.	*Fabaceae*
RIB	*Richardia brasiliensis* Gomez	*Rubiaceae*
SCI	*Schizachyrium imberbe* (Hackel) Camus	*Poaceae*
SCS	*Schizachyrium spicatum* (Spreng.) Herter	*Poaceae*
SES	*Selaginella peruviana* (Milde) Hier.	*Selaginellaceae*
SEG	*Setaria geniculata* (Lam.) Beav.	*Poaceae*
SIP	*Sida prostrata* Cav.	*Malvaceae*
SIA	*Silene argentina* (Pax) Bolquet	*Caryophyllaceae*
SIC	*Sisyrinchium chilense* Hook.	*Iridaceae*
SOI	*Solanum incisum* Griseb.	*Solanaceae*
SPR	*Spergula ramosa* Camb.	*Caryophyllaceae*
SPC	*Sphaeralcea cordobensis* Krap.	*Malvaceae*
SPD	*Spilanthes decumbens* (Smith) A.H. Moore	*Asteraceae*
SPI	*Sporobolus indicus* (L.) R. Brown	*Poaceae*
SPP	*Sporobolus pyramidatus* (Lam.) Hitche	*Poaceae*
STR	*Stenandrium dulce* (Cav.) Nees	*Acanthaceae*
STH	*Stipa hunzikeri* Caro	*Poaceae*
STN	*Stipa neesiana* Trin. et Ruprecht	*Poaceae*
STU	*Stipa tenuissima* Trin.	*Poaceae*
STT	*Stipa trichotoma* Nees	*Poaceae*
STG	*Stylosanthes gracilis* H.B.K	*Fabaceae*
TAF	*Tagetes filifolia* Lagasca	*Asteraceae*
TRA	*Tragia geraniifolia* Klozsch.	*Euphorbiaceae*
TRR	*Trifolium repens* L.	*Fabaceae*
TUS	*Turnera sidoides* L.	*Turneraceae*
VEI	*Vernonia incana* Lees.	*Asteraceae*
VEM	*Vernonia mollissima* H. et A.	*Asteraceae*
WAL	*Wahlembergia linarioides* (Lam.) D.C.	*Campanulaceae*

3. RESULTS AND DISCUSSION

3.1. GRASSLAND VARIABILITY AND BIOINDICATORS

The major trends in floristic variation related to the three ecological strata are presented in Figures 3 and 4.
The results of the partial analysis (Fig. 3) carried out on the data of each slope show, along Axis I, communities associated to eroded soil (rhexistasis), conserved soil (biostasis) and rocky outcrops. The plant species mainly related to each situation are indicated.
The spatial variation between upper and lower slope zones is pointed out by the second axis, with local variations among the three slopes.
The global analysis (Fig. 4) points out, along the first axis, the differences in plant composition in relation to the three ecological strata analysed on all slopes. The second axis shows the variability of the grassland within each site. A greater floristic resemblance between the rhexistasic zones and more heterogeneity among biostasic zones has been observed. This result is interpreted to be a consequence of the better biogeoedaphic interaction typical to areas in biostasis, where plant species can discriminate and assimilate distinct properties of the soil both within and between sectors.
At the same time, the global analysis points out the internal variability of each analysed zone generally more important than the spatial variation due to the erosion accumulation gradient existing along the slope.
On the other hand, the rocky outcrops seem to be floristically similar to rhexistasic zones. Nevertheless it seems that rocky outcrops require a more detailed sampling which would pick up all the variability present in eroded zones, well preserved ones, crevices and rocky surfaces.
Figure 5 shows the floristic composition of the analysed grassland. The 106 species recorded were represented according to their relative abundance in the three strata studied.
Twenty-three species are represented by the greatest frequency values, some of them (*Ambrosia tenuifolia, Stipa tenuissima, Piptochaetium montevidensis, Aristida spegazzini, Sida prostrata, Schizachyrium spicatum, Schizachyrium mirostachyum* and *Chloris retusa*) with particularly high percentages (around 60%). These species were accompanied by *Cynodon hirsutus, Evolvulus arizonicus, Margiricarpus pinnatus, Glandularia peruviana, Piptochaetium medium, Relbunium richardianum* and *Setaria geniculata*, with

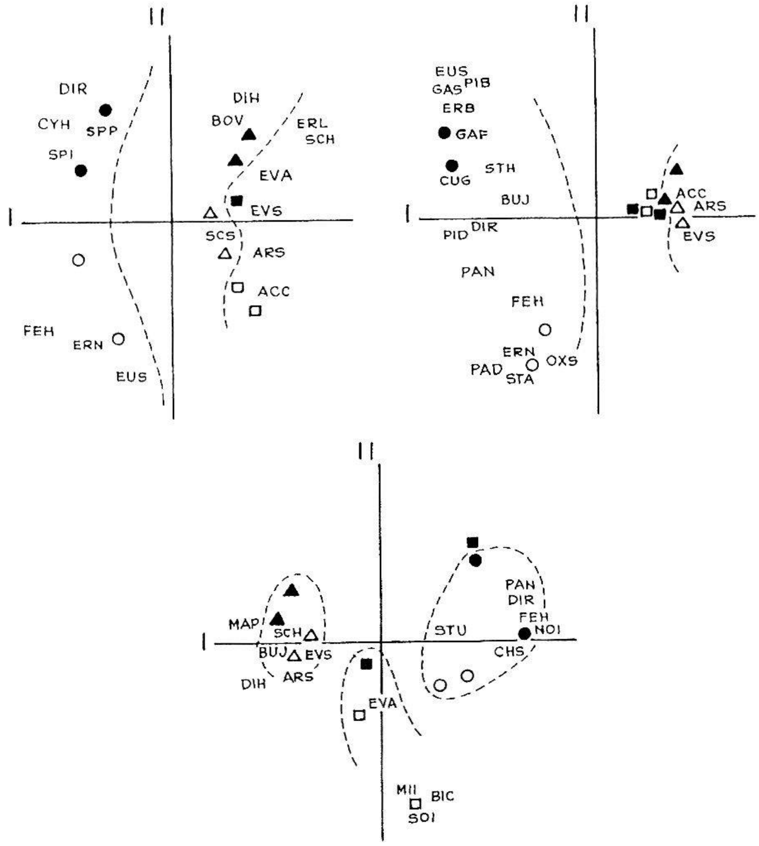

Fig. 3. Ordination of vegetation plots relative to each analysed slope. The major associated species are indicated.
Ordenación de las parcelas de cada ladera de acuerdo a la variabilidad de la vegetación. Se indican las principales especies asociadas.
Ladera 1; I (23.52%); II (16.63%), Ladera 2; I (29%); II (14.19%), Ladera 3; I (24.56%); II 14.94%)

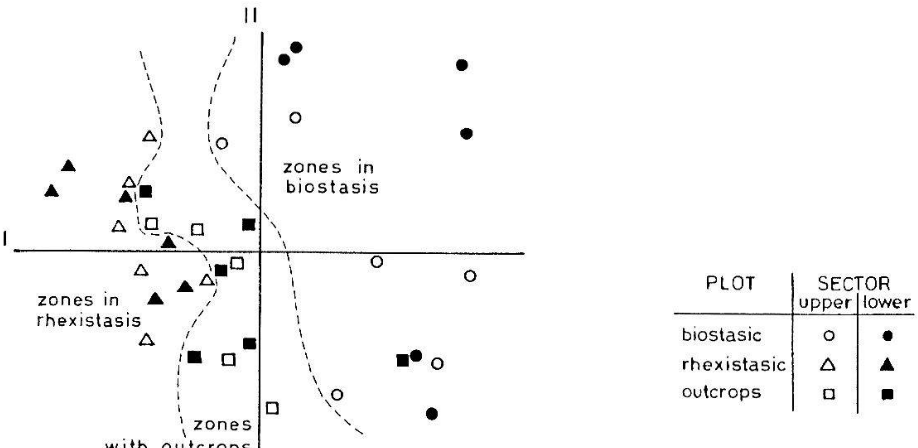

Fig. 4. Ordination of vegetation plots relative to the three analysed slopes.
Ordenación de los datos de vegetación relativos a las tres laderas. Ejes I (38.84%) y II (26.79%).

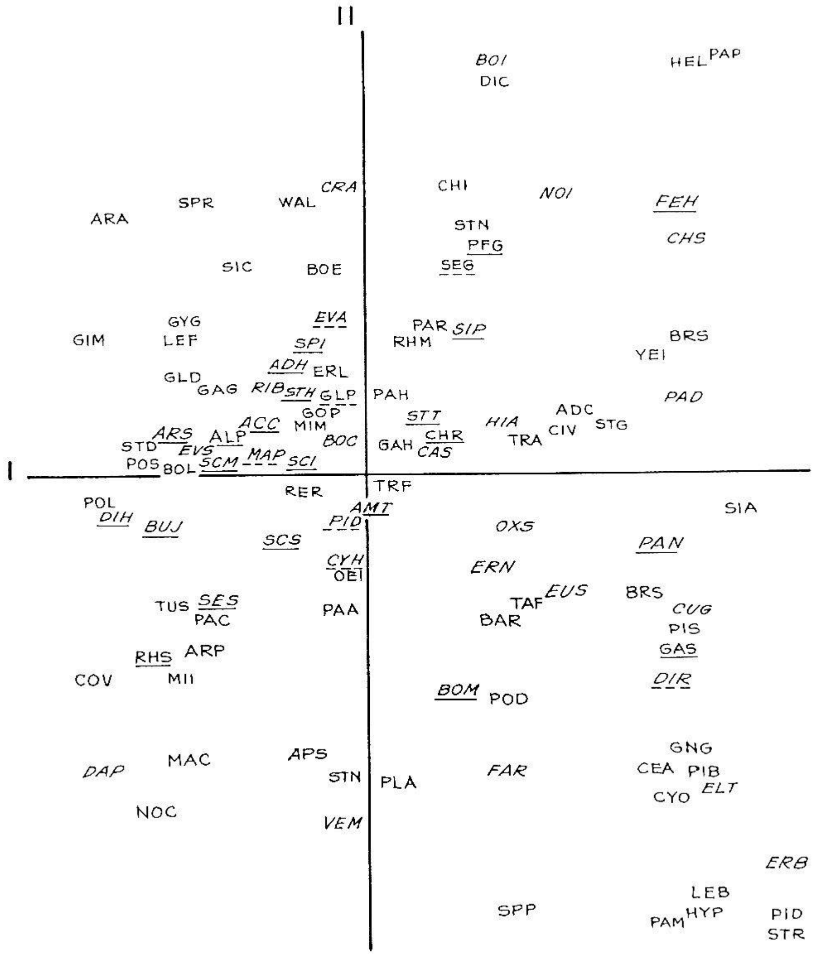

Fig. 5. Floristic composition of the studied grassland. The most common species are pointed out. (For abbreviations see Table 1).
Composición florística del pastizal estudiado. Las especies mas frecuentes están destacadas. Ver abreviaturas en la Tabla 1.
BUJ - species with indicator value
--- frequent species (10-20%), — very frequent species (20-60%)

frequency values varying from 10-20%. With the exception of *Stipa tenuissima*, most of the mentioned species are representatives of eroded sites (zones in rhexistasis or upper sectors with predominant erosion processes), have a short vegetative period (1 or 2 months) and slow growth (ALESSANDRIA and CASERMEIRO 1986).

Table 2 shows the species characteristically associated with biostasic or rhexistasic areas with their "certainty" (IC) and "importance" (II) indices (VIKTOROV et al. 1962).

Table 2. Species associations listed according to biostasic or rhexistasic zone with importance values as bioindicators.
Especies asociadas a las zonas biostásicas y rexistásicas, con sus respectivos valores de importancia.
* dubious indicator, ** reliable indicator

Species	certainty index	importance index
Biostatic zone		
Eryngium nudicaule	2.3	0.75 *
Euphorbia serpens	1.1	0.66
Festuca hieronymi	1.4	0.83
Stipa tenuissima	0.5	1.00
Stipa amethystina	2.0	0.33 *
Bouteloua megapotamica	2.0	0.33 *
Dichondra microcalyx	1.6	0.91 *
Piptochaetium medium	3.0	0.75 **
Sporobolus indicus	0.6	0.66
Chevreulia sarmentosa	1.5	0.50 *
Cynodon hirsutus	0.8	0.41
Paspalum notatum	1.6	0.83 *
Cuphea glutinosa	2.5	0.41 *
Rhexistasic zone		
Aristida spegazzini	0.8	1.00
Borreria verticilla	1.0	0.41
Schizachyrium spicatum	0.5	0.75
Stipa microstachyum	0.6	0.83
Bulbostylis juncoides	1.0	1.00
Adesmia hispidula	1.0	0.25
Dichondra holosericea	3.0	1.00 **
Stipa hunzikeri	0.4	0.66
Acalypha communis	0.5	0.83
Glandularia dissecta	4.0	0.66 **
Margyricarpus pinnatum	0.8	0.83
Schizachyrium imberbe	0.6	0.83

In spite of the clear structural differences detected by the multivariate analysis between the communities associated with biostasic or rhexistasic strata, most of the typical species of each site are represented by low bioindicator values. The data matrix analysis reveals the absence of typical species of each ecological site. The plant species environmental preferences become evident through changes in their relative abundance values. This trend is common to other grasslands of the same geographic area, associated with landscapes with predominant vectorial process (MENGHI 1987).

3.2. EDAPHIC VARIABILITY

The soil profile description pointed out some geomorphologic and edaphic differences between the two analysed strata. The rhexistasic zones are predominated by plane to plane-convex land forms covered by a detritic surface over a C-horizon with 80% coarse material or coincident with the bedrock.
On the other hand, the biostasic zones were described as slightly concave and presented patches of soil with variable coarse or fine materials. The AC-hori-

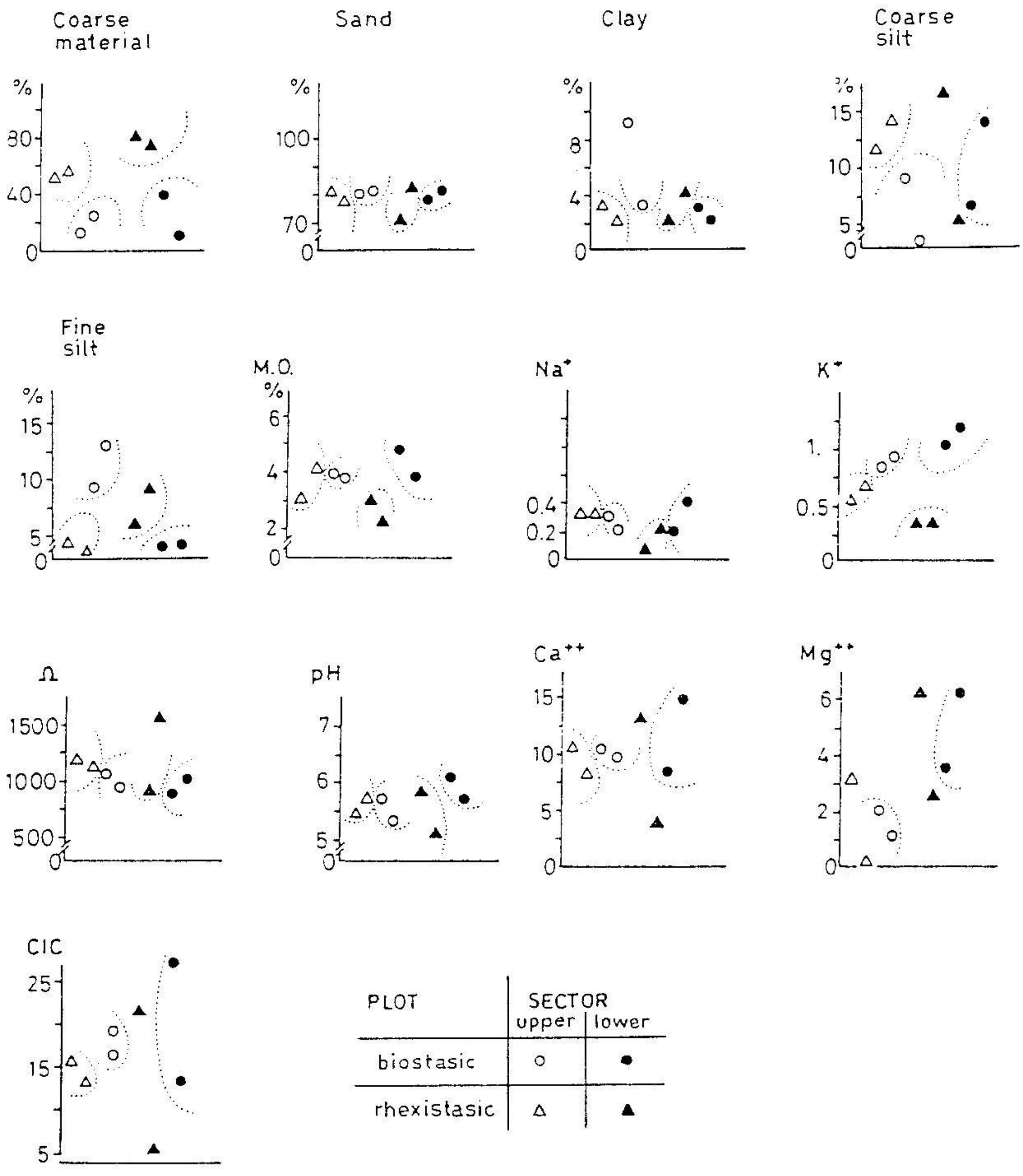

Fig. 6. Variation trend of each edaphic variable.
Tendencia de variación de cada variable edáfica analizada.

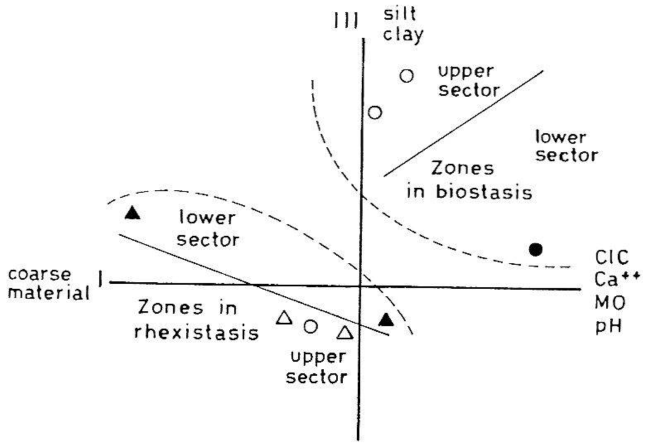

Fig. 7. Ordination of plots according to edaphic variability.
Ordenación de las parcelas según la variabilidad edáfica total.

zon 21-36 cm deep and consists of 50% coarse material with general characteristics similar to those of the upper horizon of the rhexistasic areas (Fig. 2). Although laboratory analysis pointed out spatial variation between the physicochemical characteristics of the soil (Fig. 6), at the same time they revealed uniformity in the parent rock.

The local differences were interpreted as a result of different grades of soil maturity reached by the same material when exposed to stable conditions, humidity retention and good biogeoedaphic interaction in the case of biostasic zones, or when that interaction is interrupted (by natural or anthropic causes) and when a scarce plant cover and loss of material and water predominate.

The multivariate analysis (Fig. 7) pointed out similar results. Granulometric differences were more important within the upper sector of the slope (greater percentages of coarse material in rhexistasic zones and silt and clay in biostasic zones). Towards the lower sector, the chemical differences were enhanced. The high values in CIC, organic matter, Ca^{++} and pH characterize and define the better chemical conditions of the zones with a good biogeoedaphic interaction (biostasis).

4. CONCLUSIONS

The gneissic grassland presents a clear cellular structure. Both plant and edaphic spatial variation reveal the existence of three ecological subsystems

associated to rocky outcrops, well preserved soils and more eroded zones.
The floristic spatial variation due to the topographic gradient along the slope appears masked by the greater variability existent within each ecological strata.
The rhexistasic zones, with stressing edaphic conditions, are characterized by a more homogeneous composition, floristically as well as in soil components.
The biostasic zones show greater variability. It is assumed that better biogeoedaphic interaction favours the assimilation of small local differences in the edaphic support.
There are no floristic lists exclusive of any studied strata. From this result it seems likely that different grades of edaphic maturity coexist along the slope where most of the plant species can live, and the discontinuity in natural conditions is evident through their differing spatial abundance.
The rhexistasic-biostasic mosaic presents both physical (granulometric) and chemical (mainly in CIC, OM, K^+ and Mg^{++}) edaphic differences corresponding to the plant structure.
Table 3 summarizes the major characteristics of the plant and soil relief complex of the biostasic-rhexistasic mosaic relative to the analysed gneissic slope.
The spatial variation of physicochemical characteristics and the different grades of soil maturity can be partially attributed to the structure of the underlying gneissic substrata, even though there is a close interdependence with actual plant cover and land use. The most common anthropic practices (cattle grazing and burning) also would have different local effects on the grassland along the slope and favour the predominance of edaphic restoring or erosion processes.
Most of the rhexistasic areas display exposed soil on which the associated plant species were small sized and characterized by scarce biomass, short living cycles and slow growth. They are less valued as either forage species or as plant cover. It is interpreted that these areas are particularly vulnerable to trampling and iterative fires.
In biostasic areas, however, the potential plant productivity of the ecosystem is very high, depending on correct management.
It is supposed that during drier climatic periods, overgraze combined with fire would have more drastic effects on the plant cover and favour new areas of rhexistasis.
It may be concluded that the described spatial organization model persists in gneissic environments of the Córdoba mountains at different altitudes, as well

Table 3. Relevant characteristics of the representative bio-rhexistasic mosaic of grasslands associated with gneissic slopes.
Características relevantes del mosaico bio-rexistásico representativo de pastizales asociados a laderas de gneis.

Zone in biostasis	Zone in rhexistasis
PLANT STRUCTURE Dense plant cover medium to tall sized. Predominance of tussock grasses, rhizomatous and stoloniferous. Longer periods of vegetative production.	**PLANT STRUCTURE** Sparse plant cover of small plant individuals. Predominance of annual plant species. Grasses have short life cycles and slow growing.
Upper sector *Paspalum dilatatum, Oxalis sexenata, Stipa tenuissima.*	**Upper sector** *Evolvulus arizonicus, Paronychia brasiliensis, Aristida spegazzini, Schyzachirium microstachyum, Ambrosia tenuifolia.*
Lower sector *Dichondra microcalyx, Paspalum notatum, Piptochaetium medium, Sporobolus indicus, Sporobolus pyramidatus, Eragrostis bahiensis.*	**Lower sector** *Dichondra sericea, Margiricarpus pinnatus, Bulbostylis juncoides.*
Indifferents *Festuca hieronymi, Euphorbia serpens.*	**Indifferents** *Schyzachirium spicatum, Schyzachirium imberbe, Evolvulus sericeus, Eragrostis lugens, Borreria verticillata, Acalypha communis, Richardia brasiliensis, Nothoscordum inodorum.*
SOIL TYPE "lithic Usthorthent"	**SOIL TYPE** "lithic Usthorthent"
SOIL AND RELIEF CHARACTERISTICS Plane to concave land forms with convergent fluxes of water and material. Presence of edaphic horizons (A-A1-AC-C) with abundant roots throughout the profile. Loamy texture with predominance of the finer materials. Greater values of: MO, CIC, pH and cations. Greater percentages of coarse material in the upper sector. Greater CIC and percentages of fine materials in the lower sector. Predominance of accumulation process.	**SOIL AND RELIEF CHARACTERISTICS** Plane to concave land forms with divergent fluxes. Presence of fan-shaped microrelief. Abundant surface gravel(60%). Absence of the fine material layer. A_1- and AC-horizons present high percentages of coarse materials. Predominance of erosion process.
WATER CYCLE The plant cover lessens the impact of rainfall on the soil and of the energy of water run-off. The infiltration and underlying water fluxes increase. The hydric balance is better.	**WATER CYCLE** The sparse plant cover leaves the soil exposed to a greater impact from rain and runoff velocity, to the detriment of the local hydric balance.

as the bioindicators with morphological and reproductive strategies typical of environments with external stress conditions in rhexistasis or with greater competitive capacity in biostasic areas (ACOSTA 1988, ACOSTA et al. 1992). Similar results were obtained in other grasslands with a discrete structure strongly depending on granitic substrata (ACOSTA et al. 1989, LEVASSOR et al.1981).

SUMMARY

Natural grasslands of the mountains of Córdoba (Central Argentina) on gneissic soil show a local spatial organization correspondent to the existing geomorphological variability of the slopes.
A recurrent mosaic of well-preserved soil zones ("biostasis"), locally eroded zones with residual soils ("rhexistasis") and rock outcrops was detected as typical of such environments.
It is supposed that some predominant soil characteristics would contribute to explain the grassland spatial variability.
This report focuses on the analysis of the structural characteristics of herbaceous vegetation, and on the underlying soil typology and bioindicators of the geomorphologic-edaphic complex.
The results point out a close correspondence between the grassland and some physical and chemical soil characteristics of well-preserved ("biostasis") and eroded ("rhexistasis") areas. The former present a greater heterogeneity.
The local incidence of the natural structure of gneissic substrate and the predominant anthropic interventions (fire, cattle trampling and grazing) in the observed mosaic is discussed.

RESUMEN

Los pastizales naturales de las Sierras de Córdoba (Argentina central) desarrollados en ambientes gneísicos presentan una variabilidad local correspondiente con la variabilidad geomorfológica existente en las laderas.
En una ladera típica se observa la recurrencia de un mosaico compuesto por afloramientos rocosos, zonas bien conservadas con suelos desarrollados (biostasias) y zonas erosionadas con suelos residuales (rexistasias).
Se supone que dicho complejo se correspondería con algunas propiedades edáficas de acción predominante que contribuyen a explicar la variabilidad detectada en el pastizal.
El presente trabajo está centrado en el análisis de la estructura de la vegetación herbácea, de la tipología edáfica subyacente y de los bioindicadores del complejo geomorfológico-edáfico analizado.
Los resultados muestran una estrecha correspondencia entre la organización espacial del pastizal y algunas variables físicas y químicas del suelo características de zonas bien conservadas (biostasias) y erosionadas (rexistasias). Las primeras presentaron una mayor heterogeneidad.
Se discute la incidencia en el mosaico observado tanto de la estructura natural del sustrato gneísico como de las acciones antrópicas predominantes (fuego, pastoreo y pisoteo, bovinos).

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