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CHANGES IN PASTURE COMMUNITIES SUBJECT TO BURNING IN THE CÓRDOBA MOUNTAINS, ARGENTINA

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Nomenclature follows Cabrera (1963, 1965a, b, 1967, 1968, 1970), Burkart (1974, 1979) and Correa (1984a, b)

Abstract. The successional dynamics of pastures in a representative area of the Córdoba Mountains is studied. Traditionally, the pastures are periodically burned to eliminate the phytomass that accumulates in "pajonales", areas of tall grasses that are unpalatable for cattle. This is not an intense disturbance, and it permits development until the start of a new disturbance. In this study, succession is analyzed based upon multivariate ordination techniques and diversity analysis. It is shown that the floristic composition describes a relatively clear successional sequence, and the variability in the communities is not seriously affected in its relation with the geomorphological gradient on the slopes, although many species modify their spatial niche during succession.

Introduction

The structure of the pasture ecosystems in the Córdoba Mountains (Central Argentina) is affected by several sources of variation. Those related to local geographical aspects, such as altitude, lithology and geomorphology, including slopes gradientes and edaphic development gradients, are regarded as important (Cabido *et al.* 1986, Cabido 1987, Menghi 1987, Acosta 1988). Some of these aspects, explained as "equipotentiality", "vectoriality" and "mosaicistic phenomena", according to Solntsiev's terminology (1974), are described in a previous paper (Menghi *et al.* 1989).

The traditional burning of these pastures is another source of variation. It is carried out itinerantly, under relatively little control and it affects extensive areas. The purpose is to eliminate the large grasses, such as *Festuca hieronymi, Stipa filiculmis, S. tenuissima* and *Paspalum quadrifarium* which tend to form large patches of "pajonal" which is difficult for cattle or sheep to digest (Luti *et al.* 1979, Menghi 1981, 1987). Large areas of these pastures may be considered as semi-natural (Whittaker 1974).

Menghi *et al.* (1978a, b) found that grazing on these pastures reached the highest production values per unit of maintained phytomass. Alessandria and Casermeiro (1986) showed that with moderate grazing, controlled "pajonal" burning increased the productivity and the nutritive quality of these pastures. Galera (1986) observed successional changes in frequently burned areas under varying pressure from herbivores.

The study of changes occurring in the course of succession, aids the comprehension of the structure and function of the pastures and completes the perceptions offered previously (Poissenet *et al.* 1981, Mooney and Godron 1983, Prentice and van der Maarel 1987, Pomeroy and Aberts 1988).

Another type of traditional pasture management, acting as a disturbance disconnecting the successional sere, has been studied in Mediterranean environment (Pineda and Peco 1987, 1988). In this, disturbance involves ploughing the substratum itinerantly to avoid the invasion of sclerophyllous scrub. Under this, the pasture vegetation changes dramatically with time, both in its floristic composition and in the spatial organization (Pineda *et al.* 1981a, De Pablo *et al.* 1982, Sterling *et al.* 1983, Castro *et al.* 1986, Galiano *et al.* 1987).

In the Córdoba Mountains, disturbance seems less intense than the above. Phytomass accumulation until burning is not very large and the fire is unlikely to destroy the soil microflora or affect the seed bank in the mechanically unaltered soil. The object of the present study is to set out space-time changes caused by these fires in an area of the Córdoba Mountains largely covered by pastures. It was thought that burned pasture recovery would show changes in composition and spatial organization, as they occur in Mediterranean pastures, particularly in those referring to the dimensions and characteristics of community spatial niche (Pineda *et al.* 1981b). This idea is based on the use of the spatial changes described as a reference, ex-

Table 1. Names and abbreviations of the species found in sampling.

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ACC Acalypha comnunis
ACT Acicarpha tribuloides
ADB Adesmia bicolor
ADC Adesmia corymbosa
ADH Adesmia hispidula
ADI Adesmia incana
ALA Alternanthera albida
ALP Alternanthera pumila
AMS Amaranthus sp.
AMC Amblyopetalum coccineum
AMT Ambrosia tenuifolia
ANT Andropogon ternatus
ANI Aneimia tomentosa
ARS Apium lepthophyllum
ARA Aristida achalensis
ARP Aristida pallens
ARS Aristida spegazzini
ASQ Aster squamatus
ASC Astragalus carinatus
ASD Astragalus distinens
BAA Baccharis articulata
BAC Baccharis coridifolia
BAR Baccharis rufescens
BOE Borreria verticillata
BOB Bothriochloa barbinodis
BOL Bothriochloa laguroides
BOS Bothriochloa saccharoides
BOC Bouteloua curtipendula
BOM Bouteloua megapotamica
BRP Briza paleapilifera
BRS Briza subaristata
BRA Bromus auleticus
BRU Bromus unioloides
BUJ Bulbostylis juncoides
CAB Capsella bursa-pastoris
CAR Cardionema ramosissimum
CAN Carduus nutans
CAS Carex sp.
CEA Cerastium arvense
CIV Cirsium vulgare
COO Cologania ovalifolia
COV Commelina virginica
COB Conyza bonariensis
CRA Croton argentinus
CRL Croton lorentzii
CRP Croton parvifolius
CUG Cuphea glutinosa
CYD Cynodon dactylon
CHI Chaptalia integerrima
CHS Chevreulia sarmentosa
CHH Chloris halofila
CHR Chloris retusa
DAP Daucus pusillus
DIH Dichondra sericea v. holosericea
DIM Dichondra microcalyx
DIA Digitaria ascendens
DIC Digitaria californica
DUI Duchesnea indica
ELT Eleusine tristachya
ELM Elionurus muticus
ERB Eragrostis bahiensis
ERL Eragrostis lugens
ERP Eragrostis polytricha
ERR Eragrostis retinens
ERC Erodium cicutarium
ERH Eryngium horridum
ERN Eryngium nudicaule
EUP Euphorbia portulacoides
EUS Euphorbia serpens
AVA Evolvulus arizonicus
EVS Evolvulus sericeus
FAR Facelis retusa
FEH Festuca hieronymi
GAE Gaillardia megapotamica
GAG Galactia glaucophylla
GAM Galactia marginalis
GAA Gamochaeta americana
GAF Gamochaeta filaginea
GAS Gamochaeta spicata
GEA Geranium albicans
GLD Glandularia dissecta
GLP Glandularia peruviana
GNG Gnaphalium gaudichaudianum
GOE Gomphrena perennis
GOP Gomphrena pulchella
GRP Grindelia pulchella
GYS Gymnocalyun sp.
GYG Gymnopogon grandiflorum
HES Heimia salicifolia
HMV Heterospermum diversifolium
HEA Heterothalamus alienus
HOS Hordeum stenostachys
HYP Hybanthus parviflorus
HYS Hybanthus serratus
HYA Hypochoeris argentina
HYH Hypoxis humilis
HYM Hyptis mutabilis

Table 1 (continued)

Tabla 1. Continued

CYH Cynodon hirsutus
IRD Iresine diffusa
JUD Juncus dombeyanus
JUU Juncus uruguensis
LES Leontodon nudicaulis
LEF Lepechinia floribunda
LEB Lepidium bonariense
LEM Lesquerella mendocina
LUA Lucilia acutifolia
MAN Malva neglecta
MAC Malvastrum coromandelianum
MAP Margyricarpus pinnatus
MEL Medicago lupulina
MEN Melica macra
MES Melica stuckertii
MII Microchloa indica
MIM Mitracarpus megapotamicus
NIA Nierembergia aristata
NOC Nostoc commune
NOI Nothoscordum inodorum
NOM Noticastrum marginatum
OEI Oenothera indecora
OXC Oxalis cordobensis
OXS Oxalis sexenata
OXA Oxypetalum arnottianum
PAC Paronychia chilensis
PAB Paronychia setigera
PAH Parthenium hysterophorus
PAD Paspalum dilatatum
PAU Paspalum humboldtianum
PAM Paspalum malacophyllum
PAN Paspalum notatum
PAP Paspalum plicatulum
PAQ Paspalum quadrifarium
PAA Pavonia aurigloba
PFG Pfaffia gnaphaloides
PHV Physalis viscosa
PIB Piptochaetium bicolor
PID Piptochaetium medium
PIM Piptochaetium montevidense
PIS Piptochaetium stipoides
PLY Plantago myosurus
PLM Plantago australis
POL Poa ligularis
POH Podocoma hieracifolia
POM Polygala medocina
POP Polygonum punctatum
POO Porophyllum obscurum
POS Portulaca sp.
RER Relbunium richardianum
RHM Rhynchosia minima
RHS Rhynchosia senna
RIB Richardia brasiliensis
RUC Rumex crispus
SCI Schizachyrium imberbe
SCM Schizachyrium microstachyum
SCS Schizachyrium spicatum
SCP Schkuria pinnata
SES Selaginella peruviana
SEC Senecio ceratophylloides
SEP Senecio pampeanus
SEC Setaria geniculata
SEL Setaria leiantha
SIP Sida prostrata
SIA Silene argentina
SIC Sisyrinchium chilense
SOI Solanum incisum
SOR Sonchus oleraceus
SOP Sorghastrum pellitum
SPR Spergula ramosa
SPC Sphaeralcea cordobensis
SPD Spilanthes decumbens
SPI Sporobolus indicus
SPP Sporobolus pyramidatus
STR Stenandrium dulce
STA Stenorrhynchos australis
STS Stevia satureiaefolia
STA Stipa amethystina
STF Stipa filiculmis
STX Stipa flexibarbata
STH Stipa hunzikeri
STN Stipa neesiana
STP Stipa papposa
STU Stipa tenuissima
STT Stipa trichotoma
STG Stylosanthes gracilis
TAF Tagetes filifolia
TAM Tagetes minuta
TAO Taraxacum officinale
TRG Tragia geraniifolia
TRR Trifolium repens
TUS Turnera sidoides
VEI Vernonia incana
VEM Vernonia mollissima
VIS Viola sp.
WAL Wahlenbergia linarioides
ZEL Zephyranthes longistyla

pecting fires to affect most seriously the patches of large grasses.

Material and methods

The Córdoba Mountains run for 430 km between 29° to 33° 30' S in a 110 km wide band. The highest point is Champaqui, at 2790 m. The lithology mainly consists of crystaline and plutonic rock, generally covered by acid soils except when quaternary loess sediments cover the rock on gentle slopes or flat surfaces (Vázquez *et al.* 1979). The vegetation is found in three characteristic altitudinal belts (Luti *et al.* 1979) and has been studied recently by Menghi and Luti (1982), Menghi (1987), Cabido (1985, 1987), Cabido and Acosta (1985), Cabido *et al.* (1986) and Acosta (1988) among others.

Sampling was centered on one lithological type in order to highlight the successional changes, ignoring those related to altitude or geology as sources of abiotic variations. The tertiary conglomerate zone of El Cuadrado was chosen. Its relief is gently undulating and the slopes are straight or almost concave. The correspondence between the spatial variation of the communities and slope morphology has been previously studied on well preserved or not recently disturbed slopes (Menghi *et al.* 1989). This area is representative of considerable areas of moderately grazed pasture.

Several neighbouring slopes were chosen with similar topographic and pedological characteristics oriented to the north, but which had been burned at different times. The sampling followed a transect from the upper to the lower part of each slope. Ten 2 x 6 m plots were placed regularly in each transect, with longer side perpendicular to the slope direction. The frequency of each species in each plot was determined using 10 elemental 20 x 20 cm sampling quadrats placed at random. The data were collected during the same growth season (summer of 1986), thus avoiding differences owing to meteorological and phenological variation. Eleven slopes were sampled. Two had been burned four months previously, while the rest consisted of three repetitions of slopes burned one, four and nine years before.

The data were analyzed using correspondence analysis (Benzecri 1973) in order to define space-time trends. A pattern diversity analysis was carried out to reveal the spatial niche behaviour of species and communities during succession (Pielou 1977, Pineda *et al.* 1988). The parameter H(P/Ej) (De Pablo *et al.* 1982) was used as a representation of a measure of the equitability of species j abundance distribution along a group of regularly located sampling plots. This parameter is a non-standardized measure of the spatial niche width of the species. It was unnecessary to use the standardization parameter $A=H(P/Ej)/H(P)_{max}$ (Pineda *et al.* 1981b) - where $H(P)_{max}$ is the maximum alpha diversity value obtained from the distribution of species abundance in all plots - because the number of basic sample units (10) was the same in every case.

Results and discussion

A total of 195 species were found in the 110 sample plots (Table 1). Only the 176 species whose presence exceeded 2% of the total sampling quadrats were considered for numerical analysis. The number present in each plot was highly variable, and the number on each slope was relatively similar. This number tends to be higher on the oldest slopes since burning, although a clear successional variation trend was not observed (Table 2).

The ordination analysis showed a relatively clear successional variation in the floristic composition from the negative part of axes 1-3 towards the positive end (Figure 1). The species with high loadings associated with each group defined in Figure 1 are shown in Table 3 while some of the most characteristic responses to successional change are shown in Figure 2. The initial stage of succession is characterized by the relative abundance of *Ambrosia tenuifolia, Stipa flexibarbata, S. filiculmis, Piptochaetium montevidense* and *Eragrostis lugens* among others. The abundance of some of these species hardly varies with time. Stabilized pasture is characterized by *Festuca hieronymi, Cologania ovalifolia, Dichondra microcalyx* and *Heterospermum diversifolium*, among others. These species are characteristic of stable "pajonales", where there is large accumulation of phytomass (5000 kg/ha; Menghi *et al.* 1978). The palatability for domestic herbivores is low and the grasses are regularly burned. This provokes a new successional cycle.

Table 2. Number of species found in 110 north oriented plots on 10 sites along each of the 11 Tertiary conglomerate slopes, burned at different times.

Time since burning	Slope	Number of species	Mean number
4 months	1	113	
	2	93	103.0
1 year	3	108	
	4	109	
	5	108	108.3
4 years	6	104	
	7	83	
	8	93	93.3
9 years	9	140	
	10	114	
	11	107	120.6

Table 3. Average frequency values (in brackets) of characteristic species of each group of plots shown in Figure 1. These values were obtained from groups of 20 plots (2 slopes with 10 plots each in initial stages, 4 months), and groups of 30 plots (3 slopes) in the remaining successional stages. Species are identified by the site which produced their highest value: E=upper eroded zones (first three plots along the transect); T=intermediate zones (next four plots); C=lower accumulation zones (last three plots).

4 months	1 year	4 years	9 years
Ambrosia tenuifolia (.040)T	Schizachyrium imberbe (0.32)E	Piptochaetium montev. (.046)C	Festuca hieronymi (.060)T
Piptochaetium montev. (.045)C	Stipa filiculmis (.042)T	Paspalum notatum (.240)C	Stipa filiculmis (.050)T
Eragrostis lugens (.038)E	Schkuria pinnata (.038)T	Dichondra microcalyx (.050)C	Cologania ovalifolia (.060)T
Aristida spegazzini (.034)E	Sida prostrata (.030)T	Eragrostis lugens (.049)T	Dichondra microcalyx (.040)C
Schizachyrium imberbe (.033)E	Chloris retusa (.040)E	Festuca hieronymi (.035)T	Heterospermun diversif. (.040)T
Schizachyrium spicatum (.037)E	Dichondra microcalyx (.280)C	Chloris retusa (.045)E	Sida prostrata (.030)T
Stipa filiculmis (.036)T	Borreria verticillata (.030)E	Chevreulia sarmentosa (.030)T	Chevreulia sarmentosa (.030)T
Schkuria pinnata (.036)T	Aristida spegazzini (.044)E	Stipa filiculmis (.040)T	
Sida prostrata (.049)T	Paronychia chilensis (.028)E	Stipa tenuissima (.033)T	
Tagetes filifolia (.037)C	Rhynchosia senna (.038)E	Ambrosia tenuifolia (.041)T	
Setaria geniculata (.039)T	Dichondra sericea (.035)E	Bromus unioloides (.040)C	
Paspalum notatum (.037)C		Sida prostrata (.053)T	
Oxalis sexenata (.030)T		Hypochoeris argentina (.037)C	
Dichondra microcalyx (.039)C		Gamochaeta spp. (.035)E	
Gamochaeta spp. (.034)E			

Variation in the pasture composition along slope gradients has been described in numerous studies, including some carried out in this area (García-Novo *et al.* 1969, Pineda *et al.* 1981a, Sterling *et al.* 1983, Menghi 1987, Menghi *et al.* 1989). Nevertheless, in this group of slopes with different successional ages, the distribution of plots along continuous geomorphological gradients is discernable only in the case of the older successional pastures (ellipses in Figure 1) and unclear

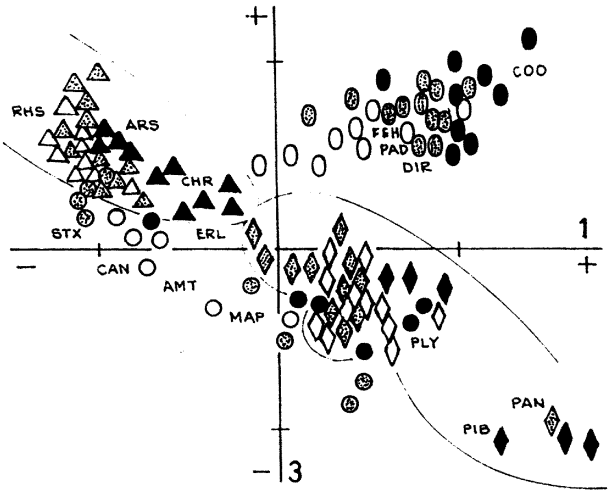

Figure 1. Correspondence analysis of all sample plots on 11 pasture slopes with different successional ages after burning. Circles= plots on slopes burned 4 months previously; triangles= 1 year; diamonds= 4 years; ellipses= 9 years. The shading of the symbols refers to the geomorphological position: open= upper zones on the slopes; dashes= intermediate; solid= lower. Some characteristic species are represented for each stage. See Table 1 for abbreviations.

on other slopes. The behaviour of characteristic species seems to indicate a certain regularity (Table 3): after 4 months and 1 year since distrubance, there are 5 and 7 characteristic species respectively associated to eroded sectors of the slopes (E). In more advanced stages, characteristc species belonging to these zones are not so abundant or are absent (2 and 0 after 4 and 9 years respectively). Fire appears to favour these species and they all disappear during the course of succession with the invasion of plants that promote edaphic stability in the advanced successional stages (Levassor *et al.* 1981, Sastre *et al.* 1982).

Separate correspondence analysis was performed for each slope (Figure 3). This reduced the noise that the simultaneous analysis of all the data could have produced in the first ordination analysis showed in Figure 1. The results indicate a clear floristic gradient along the slopes in the established "pajonales" and also in the preceeding stages (Figure 3, 9 years and 4 years respectively). The community structures along the slopes do not appear to be much affected by fire disturbance, in contrast to the effect of severe disturbances elsewhere in similar ecosystems.

Table 4 shows the spatial niche width of the species along the slopes. The average value of the parameter H(P/Ej) measured on each slope for each species at each successional stage is used. These values do not indicate a clear successional sequence in average niche width (0.72, 0.78, 0.77, 0.74). Nevertheless, the species with low width tend to be more abundant with succession (34, 34, 35, 48). Their relation with those of wide distribution along the slopes also seem to increase (0.93, 1.00, 1.20, 1.68). However, this is not very notable between the beginning and the end of succession, perhaps because after fire, the pastures still retain

a structure similar to the one prior to burning. This structure seems to be lost after the first year and recovers with time (Dell *et al.* 1986, Casado 1987).

The regularities pointed out in the individual behaviour of some species are also shown in Table 5. The progression in the recovery of the "pajonal" is clear: *Festuca hieronymi, Bromus unioloides, Paspalum plicatulum, Cologania ovalifolia* and *Dichondra microcalyx* change from a restricted spatial distribution at the start of succession to a widespread distribution across the whole slope in the more mature stage. Other species, such as *Evolvulus sericeus, Stenandrium dulce* or *Chaptalia integerrima*, clearly behave like colonizers, being distributed across a whole recently burned slope and then later disappear. The majority of the species such as *Ambrosia tenuifolia, Stipa filiculmis, Relbunium richardianum, Schizachyrium imberbe*, stay in the pasture permanently. Others such as *Andropogon ternatus,*

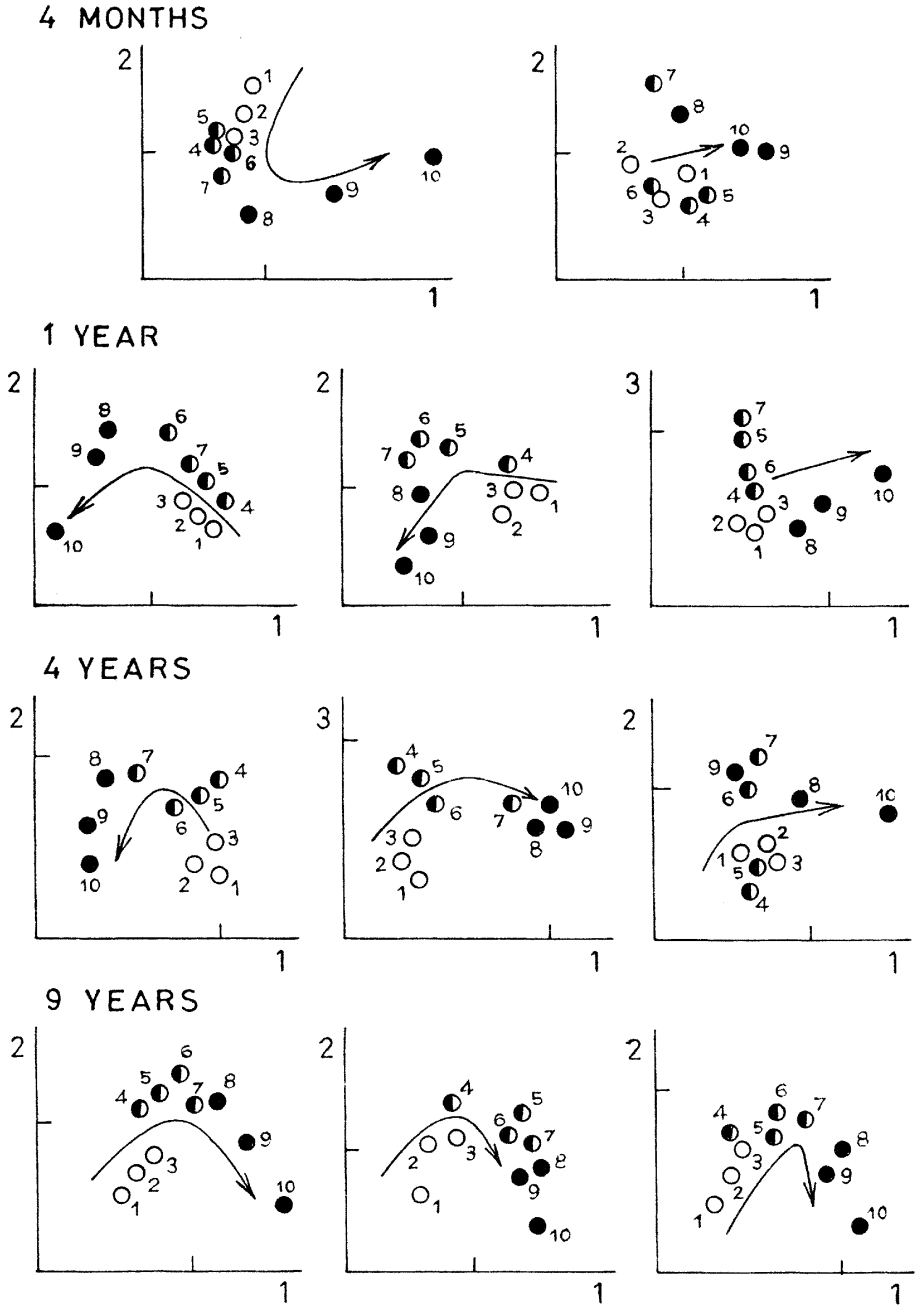

Figure 2. Variation in mean frequencies (ordinate) of some characteristic species of each successional stage (abscissae).

Poa ligularis and *Aster squamatum* colonize specific parts of the slopes and then inmediately disappear.

The spatial distribution of many species, tipically *Melica stuckertii, Stipa neesiana, Commelina virginica, Taraxacum officinale* and *Eleusine tristachya*, seem not to be affected by fire. These species remain on certain segments of the slopes and maintain this type of distribution throughout succession.

Fire seems to favour the spread of some species across the slopes. This is the case, for example, in *Alternanthera pumila, Aristida spegazzini, Borreria eryngioides, Stipa tenuissima* and *Glandularia peruviana*. During succession, however, these species tend to specialize, occupying restricted zones along the slopes and maintain this new spatial distribution during maturity.

Finally, Table 4 includes the number of species palatable to cattle in each successional stage. Palatability is estimated according to field observations that were contrasted with the knowledge of local graziers. Although the number of species is slightly higher in the mature stages, their successional evolution is not clearcut. Based on these considerations, traditional burning seems more justified by the initial

Table 4. Total number of species and average niche width at four successional stages. The average niche width was measured using the parameter H(P/E) (Pielou 1977, Pineda et al. 1981b). For individual species niche width and spatial behavior, see Table 5.

	Time since pasture burning			
	4 months	1 year	4 years	9 years
Number of species, Nt	103	108	93	120
Average niche width, H(P/E)	.72	.78	.77	.74
	g l	g l	g l	g l
Number of species with high (g) and low (l) width	26 34	34 34	30 35	29 48
Relation l/g	.93	1.00	1.20	1.68
Relation l/Nt	.56	.50	.60	.62
Number of species consumed by cattle, c	32	30	27	35
Relation c/Nt	.31	.27	.29	.29

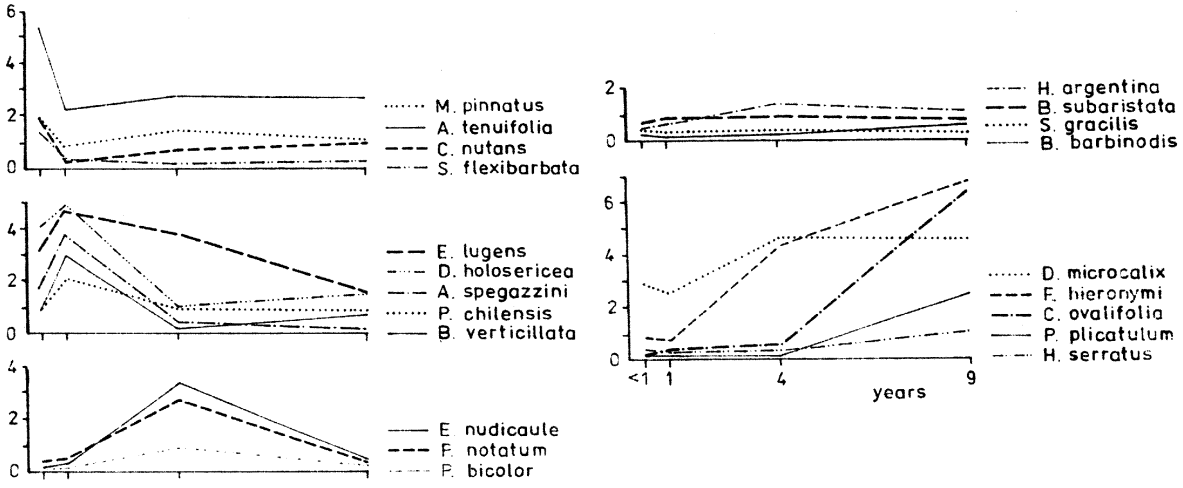

Figure 3. Separate correspondence analyses for data from each of the 11 slopes. The shading of the symbols refers to the geomorphological position of the plots from the upper (open symbols) to the lower (solid symbols) zones of the slopes. The half solid symbols indicate intermediate zones.

Table 5. Spatial niche width values (in parentheses) of species in pastures at four successional stages. The measure of the niche width is maximum when the species show the same abundance value, apart from 0, in the ten plots along the transect. This value is $\log_2$ 10-3.32. Those species with a value higher than or equal to 2.50 are considered to have a high niche width (generalists); those with a value equal to or less than 1 have a low width (specialists). The mean value was 2.01. The species name is underlined if its spatial behavior did not change with succession and is double underlined if they showed changes. An asterisk denotes species preferred by cattle. For species names, see abbreviations in Table 1.

4 months				1 year				4 years				9 years			
g		l		g		l		g		l		g		l	
AMT	2.9	ADC*	0.0	ACC*	3.2	ACT	0.0	ALP	2.5	ADC	1.0	ACC	2.5	ALP	0.9
ALP*	2.9	ANT*	1.0	ADC*	3.1	ARP*	0.0	AMT	2.5	AMC	0.0	AMT	2.9	ANI	0.0
ARS*	2.6	ASQ*	0.0	ALP	2.6	APS	1.0	ARS*	2.5	APS	1.0	BOC*	2.5	ADC*	0.6
BOE*	2.6	BAR	1.0	AMT	3.0	BAA*	0.0	BOE	2.6	ARP*	0.0	BRS*	2.6	ASC	0.0
BOV	2.6	BOL*	1.0	ARS*	3.0	BAR	0.0	BOL*	2.6	BAA	0.0	BRU*	3.3	ARS*	0.9
BUJ*	2.7	BRU*	0.0	BOE	3.2	BOC*	0.7	BRS*	2.7	BAC	0.0	COQ	2.6	BAA*	0.0
CHR*	3.2	CAR	0.0	BOV	3.0	BOM	1.0	CAS*	3.0	BRP*	0.0	CUG	3.0	BOE	1.0
CUG	3.1	COV	0.0	BRS*	2.8	COQ	0.0	COB*	2.5	BUJ*	0.0	CHS	2.7	BRP*	0.0
CYH*	2.9	CYD*	0.0	BUJ*	2.9	CUG	0.9	CUG	2.6	COV	0.9	CHR*	3.3	BUJ*	0.9
ERL*	2.8	CRP	0.0	COV	2.5	CYD	0.9	CHS	3.2	CYH*	0.2	DIM	3.3	COV	1.0
EUS	3.0	DAP	0.0	CHI	2.5	DIA*	0.0	CHR*	3.1	DIA*	0.9	DIH	3.2	CYH*	0.0
EVS	2.5	DIM*	0.0	CHR*	3.2	EVA	0.0	DIM*	3.2	ELT*	0.0	ERP*	2.8	CAS*	0.7
GLP	3.2	DIC*	0.0	DIM*	2.6	ERP*	1.0	ERL*	3.0	EUP	0.0	EUS	3.0	COB	0.6
GAM	2.9	ELT*	0.0	DIH	3.2	GAA*	0.0	ERN	3.2	GAE	0.0	FEH*	2.7	CHH*	0.8
OXS*	2.9	ERH	0.0	ERL*	3.2	GDE	0.0	EUS	3.1	GAS	0.0	HYA*	3.1	DIA*	0.9
PIM*	2.8	ERN	1.0	ERN	3.0	GLD	0.8	EVA	2.7	GLD	0.0	OXS*	2.9	ERH	0.0
SEG	3.1	EUP	0.9	EUS	3.2	GNG	1.0	FEH*	3.1	GNG	0.0	PAL*	2.7	ERN	0.0
SIP	2.7	FAR	0.0	MAP	2.5	HYA*	1.0	GAM	3.2	GOP	0.0	PAP*	2.6	EVA	1.0
STF*	3.1	FEH*	0.9	MIM	2.6	HYP*	0.0	GLP	2.8	LEB	0.0	PFG	2.7	GAA	0.0
STX*	2.7	GAE	0.0	OEI	2.8	NIA	0.0	OEI	3.3	LUA	1.0	PIM*	3.0	GLP	1.0
STH*	2.6	HYS	0.6	OXS*	3.1	NOM	0.0	PAC	2.8	MES*	0.0	RHS*	2.9	HOS*	0.8
STR	2.9	JUD*	0.8	PAC	3.1	PAU*	0.0	PAN*	3.1	NOM	0.9	RER	3.1	HYM	0.7
STG	2.5	LEB	0.0	PIM*	3.2	PID*	0.9	PIM*	3.0	OXA	0.0	SCI*	2.8	LEM	0.9
SCI*	3.0	LUA	0.9	RER	2.6	PIB*	0.0	SCI*	2.9	PAH	0.0	SCS*	3.2	LUA	0.8
SCS*	2.7	MES*	0.0	RHS	2.6	PIS*	0.0	SEC	2.7	PAU*	0.0	SEG*	3.2	MIM	0.0
SCP	2.5	OEI	0.9	SEG*	2.9	RHM	0.0	SIC	3.1	PFG	0.8	SIP	3.2	NOM	1.0
		PAD*	0.9	SIP	3.0	SEC	0.0	SOI	3.2	PIB*	0.9	SIA	2.3	OXC	0.0
		PAP*	0.9	SPI*	2.6	SPR	0.0	STF*	2.9	RHM	0.9	STF*	2.9	PAC	0.8
		PIS*	0.0	STF*	3.0	SOP*	1.0	STU*	3.0	SIC*	1.0	TAF	3.2	PAH	0.9
		POL*	0.8	STH*	2.9	STS	1.0			SPD*	1.0			PAN*	0.0
		SOP*	0.0	SCP	3.2	STX*	1.0			SCP	0.9			PHV	0.8
		STN*	0.9	SCS*	3.2	STP*	0.0			SPI	0.0			PIO*	0.0
		TAO*	0.0	SPD	3.2	STA	1.0			STA*	0.0			POM	0.0
				STR	2.8	ZEL	0.0			TAO*	0.0			SEP	0.0
										WAL	0.0			SCP	0.0
														SCM*	0.0
														SIC*	1.0
														SPD	0.0
														SPP*	0.0
														STA*	0.8
														STU*	0.9
														STG	0.0
														TAM	0.9
														TAO	0.0
														TUS	0.0
														VEM	0.0
														VEI	1.0
														VIS	0.0

productivity and palatability increase and by the elimination of tall grasses that impede grazing, than by an increase in the richness of consumed species. The analysis of pasture nutrient quality seems to justify this practice (Alessandria and Casermeiro 1986). Erosion and the disappearance of native species in natural pastures as a result of fire, on the other hand, signal the need for careful conservation management of this resource (Herrera *et al.* 1978, Luti *et al.* 1979).

Conclusion

Regular burning of pastures is a traditional activity which changes the floristic composition and spatial distribution of species. It also causes marked variability in the ecosystem. Dynamic criteria and other nonbiotic factors should thus be included in the typology of the pastures in mountaineuos regions (Menghi *et al.* 1989). The successional sequence after burning is relatively clear with respect to the variation of characteristic species abundance, many of which undergo changes in their spatial distribution along the slopes. Average spatial niche width does not show a clear trend with succession, but the number of species with low niche width tend to be more abundant in mature stages, particularly in those associated with the Festuca hieronymi "pajonales" which are specially affected by fire.

The general community structure of the Córdoba montane pastures is not severely disturbed by fire. During succession, there is always close correspondence between the biocenotic variability on the one hand, and erosion, material transit and material accumulation along the slope on the other. This contrasts with the results obtained for work with Mediterranean pastures which we already quoted. Nevertheless, the most abundant characteristic species in post-fire stages belong to the eroded upper zones on the slopes, excepting the mature pastures. Fires only superficially affect edaphic erosion processes.

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