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THE EFFECT OF HUMAN FACTORS (CUTTING, BURNING AND UPROOTING) ON EXPERIMENTAL HEATLAND PLOTS[1]

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ABSTRACT.- Regeneration response after prescribed burning, cutting and uprooting in experimental heathland plots dominated by Erica autralis *subsp.* aragonensis, *was studied. The highest percentage cover of annual species was observed two years after the treatment. From that moment the therophytes tended to decrease and were replaced by perennial species natural to the community. The temporal heterogeneity calculated shows the greatest changes in the initial stages. Regeneration was by an autosuccession process, slower in the case of the uprooted plots due to the greatest impact.*

RÉSUMÉ.- On étudie la réponse de la régénération après brûlage, coupe et l'arrachage dans les parcelles expérimentales de bruyère avec dominance de E. australis *subsp.* aragonensis. *On observe un plus grand pourcentage de couverture d'espèces annuelles après deux ans de traitements. À partir de ce moment, les therophytes diminuent, et sont remplacées par des espèces pérennes, propês de la communautè. Grâce au calcul de l'hétérogénéité temporelle, on met en évidence les changements les plus importants lors des les premières étapes. La régénération se produit par un processus d'autosuccession, avec une récupération plus lente, car l'arrachage a été très drastique.*

RESUMEN.- Se estudia la respuesta de regeneración tras quema, corta y arranque en parcelas experimentales de brezal, con dominio de E. australis *subsp.* aragonensis *(L). Se observa el mayor porcentaje de cobertura de especies anuales a los dos años de los tratamientos. A partir de ese momento, las terófitas tienden a disminuir, siendo sustituidas por especies perennes, propias de la comunidad. Mediante el cálculo de la heterogeneidad temporal se ponen de manifiesto los mayores cambios en las etapas iniciales. La regeneración se produce por un proceso de autosucesión, siendo el arranque más drástico por tanto muestra de una recuperación más lenta.*

Key-words: *heathlands, prescribed burning, cutting, rooting out, regeneration, species diversity, heterogeneity.*

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The present state of vegetation partly depends on the human factors which have influenced it, and still which continue to do so (LE HOUEROU, 1980). Human pressure on ecosystems in the Mediterranean Basin goes back to ancient times (HAVEH, 1974; TRABAUD, 1987). The present structure of communities reflects past performance and at the same time conditions the future (GODRON *et al.*, 1978).

León province is an example of what may result from particularly intense, above average human action. The degradation of climax forests due to the significant increase in wildland fires, excessive cutting and overgrazing in some areas, together with the neglect of pasturage and cultivation in others, have given rise to enormous shrub areas covering 33% of the total area, according to figures supplied by the Ministery of Agriculture (1984). This figure is above the national average, estimated at 26% (Dirección General de Acción Territorial y Medio Ambiente, 1978).

In spite of their large size, these communities have been considered marginal areas from the point of view of territorial development and have hardly been made use of (DE JUANA, 1981). Any study aimed at determining the most suitable form of management for any potential use is of great interest.

Concern about the use and improvement of shrub ecosystems is present in some classic papers (BELLOT, 1962, VIEITEZ *et al.*, 1966) and has become important again in recent years (LUIS *et al.*, 1988; CALVO *et al.*, 1989, FERNANDEZ *et al.*, 1990).

The main purpose of this paper is to analyze regeneration in heathlands —the most commonly occurring shrub formation in León province —after they have been subjected to different experimental disturbances (burning, cutting and uprooting), thus simulating the most common destructive impacts on these ecosystems caused by humans. The response of the plant community and some structural changes occurring in the course of time are compared. Detailed knowledge of such processes is a first step essential in determining the most suitable way of making good use of and improving these communities.

1. Materials and methods

1.1. *Description of the study areas*

Experimental treatments were carried out in two areas of León province, dominated by shrub communities and situated in the far north of the high land near the mountain region.

—"Majada de Setibar": situated in the Cubillas de Rueda municipal district (UTM coordinates: 30TUN243292) at an elevation of 1150 m.

—"Monte Cota Isestil": 5 Km north of the above, near the rural centre of Palacios de Rueda (UTM coordinates: 30 TUN 248336), at an elevation of 1000 m.

The shrub community which characterizes the two areas is similar, with *Erica australis* subsp. *aragonensis* (Willk) P. Cout as dominant species, although Majada de Setibar is richer in ligneous species, *Arctostaphylos uva-ursi,* (L.) Sprengel, *Erica umbrellata* L., *Calluna vulgaris* (L.), Hull; *Chamaespartium tridentatum,* (L.), P. Gibbs *Halimium alyssoides* (Lam.), C. Koch, than Cota Isestil.

1.2. *Sampling*

Four square plots measuring 100 m^2, were established in each sampling area and in those shrub areas of more homogeneous characteristics. One of them was kept as a control and the other three were subjected to burning, ligneous species cutting and uprooting of existing vegetation.

Treatment was carried out in July 1985, except for the uprooting of the Cota Isestil plot, which was in July, 1986. The previous species composition of each plot is described in LUIS *et al.,* (1988). The herbaceous vegetation percentage before treatment was not over 1%. Majada de Setibar was burnt in a fire which had nothing to do with the experiment in September 1985. So in this area the superimposition of the effect os this second fire on that of the treatment carried out (mainly cutting) is studied.

In order to analyse temporaly vegetation change, five annual inventories of 1 m^2 samples in each plot were taken from June 1987 to June 1991. All the species present were recorded, their importance being expressed in terms of vertical projection cover percentage. These samples were chosen at random during the first year and recorded for repetition in later controls.

1.3. *Data Processing*

Species diversity and its components, richness (number of species) and evenness (H'/H' max, PIELOU, 1969) were calculated from the results obtained by means of the SHANNON-WEAVER index (1949). Alpha diversity, characteristic of each inventory, and gamma diversity, characteristic of each plot and sampling period, were determined. Spatial heterogeneity, or Beta diversity (BLONDEL, 1985) was calculated as the difference between $H'\gamma$ and the average of the corresponding $H'\alpha$. The same method was also used in determining temporary heterogeneity between sampling pairs in consecutive years.

2. Results and discussion

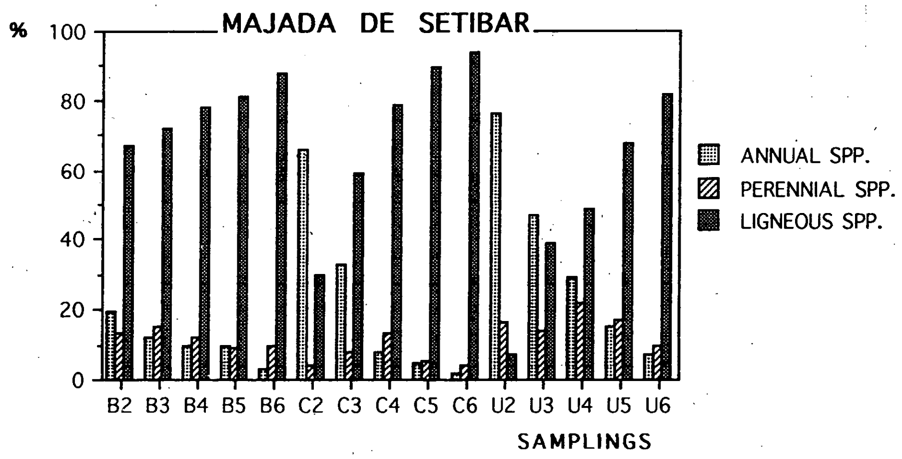
Table 1 shows the five species with the greatest cover in each plot and sampling period after experimental treatment, as well as shrub species cover in each plot in its original situation. More ligneous species appear in Majada de Setibar than Cota Isestil, although *Erica australis* subsp *aragonensis* tends to be more abundant in both areas. The importance of initial species composition is apparent in the greater similarity between samples from each area and, within that, between those from the same plot.

TABLE 1

Cover values (%) of five species with the most important values in each plot and sampling period (B = Burning Plot. C = Cutting plot. U = Uprooting plot. The number indicates the time after treatment. *(Valores de cobertura en % de cinco especies con los valores más importantes en cada parcela y período de muestreo. B = parcela quemada; C = parcela cortada; U = parcela arrancada. El número indica el tiempo después del tratamiento.*

	B0	B2	B3	B4	B5	B6	C0	C2	C3	C4	C5	C6	U0	U2	U3	U4	U5	U6
MAJADA DE SETIBAR																		
Arctostaphylos uva-ursi	65	27	21	25	23	41							54					
Erica australis	35	25	30	34	44	37	32	7	29	34	34	43	41		6	12	14	19
Aira caryophyllea		13	5	6				22	15					15	26	11		
Avenula marginata		4																
Quercus pyrenaica	12	3	4	11	4	6	20						15					
Hypochoeris radicata	3															5		
Tuberaria globularifolia				4					4	5	4						2	
Halimium alyssoides	7				3	4	36	2	5	10	7	7	10	2	10	24	19	36
Erica umbellata	25				3	4	41		3		11	15	23					4
Airopsis tenella								3										
Tuberaria guttata								3						2				
Chamaesp. tridentatum	7						10			4		5	14					
Calluna vulgaris	25						20			4		4	27			4	9	13
Halimium umbellatum	3						6				5	4	8					5
Lolium perenne														3				
Evax carpetana														1	6			
Agrostis capillaris															4		5	
COTA ISESTIL																		
Erica australis	79	16	17	37	47	34	62	25	26	45	28	54	74	1	15	29	18	
Lotus corniculatus		9	13		2	6			3			4		4		3	6	
Aira caryophyllea		3	5	5	2									2	3	4	2	
Thymus zygis		3	3	4			6	1			3		6					
Arenaria montana		3								3								
Hypochoeris radicata		3				4					33				2		2	
Avenula marginata			3	8	3			2	6	3	7	5		2	3	2	8	
Centaurea janeri				3		4		1	3	4	2	4						
Plantago holosteum					3			1										
Agrostis capillaris									7	5								
Logfia minima														2				
Crucianella angustifolia															3			
Potentilla erecta																3		

If the percentage of biological types is compared (Fig. 1), in Majada de Setibar there is a clear tendency for the ligneous species to gradually increase cover at the expense of the annual species, which tend to decrease.



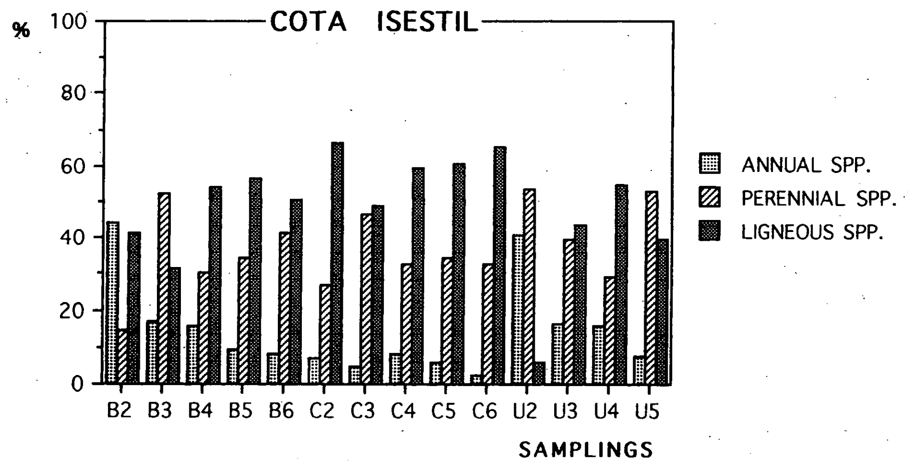


Fig. 1. Percentage of different biological types, in terms of their cover, in each plot and sampling period. *(Porcentaje de los diferentes tipos biológicos, según su cubierta vegetal, en cada parcela y para cada periodo de muestreo).*

This is more marked in the cut and uprooted plots, as a predominance of shrub was recorded from the first stages in the burnt ones. In this area the effects of the fire occurring a few months after the experiment must be taken into consideration. The cut plot had almost no ligneous species but conserved enough annual ones to allow the fire to continue its progress through them. This wildland fire was much more intense than the one caused experimentally, since the vegetation was drier. This meant that recovery was slower in the initial stages (LUIS *et al.*, 1988). The higher proportion of ligneous species in this areas's burnt plot in the initial stages is probably due to the fact that it did not undergo another fire because of its lack of surface biomass. In Cota Isestil the highest cover for annual species was recorded in the second year after treatment. Cover percentages for ligneous species are lower than those in Majada de Setibar with the increase occurring less markedly. The general tendency is towards a decrease in the proportion of annual species, except in the cut plot where its significance is slight during the whole study period. The proportion of perennial species is greater in this area than in Majada de Setibar.

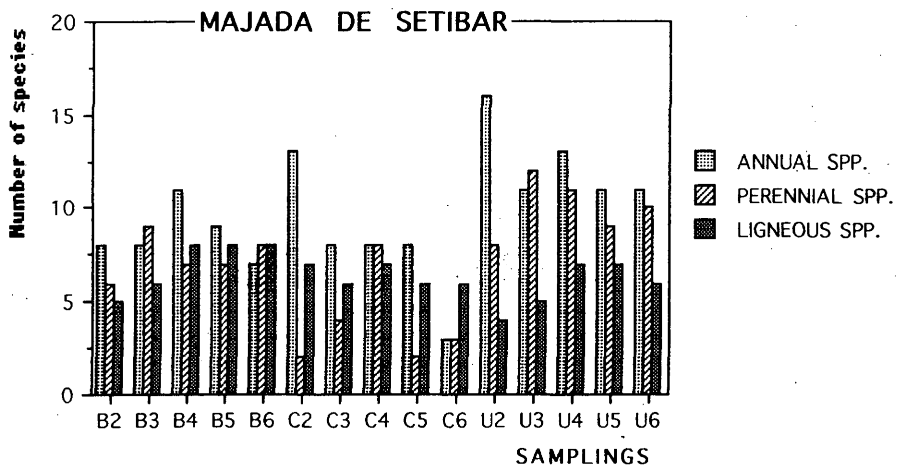
Greatest cover by therophytes occurred two years after treatment. This coincides with TRABAUD's (1980, 1987) findings, which indicate the invasion of pioneer species in the initial successional stages, taking advantage of the open spaces left after the elimination of shrub biomass. These species are later replaced by perennial species natural to the community.

Figure 2 shows the percentages of biological types in terms of richness. It shows the greatest number of annual species two years after cutting and uprooting in Majada de Setibar. This occurred in the burnt plot in the fourth year.

There are hardly any changes in the number of species of biological types in the cut plot in Cota Isestil. The other two treatments produced maximum annuals in the fourth year. CASAL (1987) recorded the highest number of therophyte species in the first successional stages.

CASAL *et al.*, (1984) comment that after clearing no important changes are observed in herbaceous species, while the appearance of therophytes are noted in the first stages after burning. In the Cota Isestil cut plot the number of annual species hardly differs from that for the other two plots. However, this species cover is far less in the initial stages.

Total vegetation cover tends to increase as time passes, though with oscillations (Table 1). The appearance of values over 100 % is explained by strata superimposition. Two years after treatment the lowest values are usually recorded (there is no data no the first year), but within each area the greatest cover in the first stages is in the burnt plot, probably as a result of the fertilizing effect of the ashes. The uprooted plots have the lowest cover, as is to be expected, as regeneration can only be from seeds. On the contrary, most species are reproduced vegetatively after cutting or burning, which allows them to occupy space more quickly as they have a perfectly developed root system available. This adaptative mechanism occurs frequently in many species natural to the Mediterranean climate as a result of long years of coexistence with fire, cutting and grazing (NAVEH, 1974).



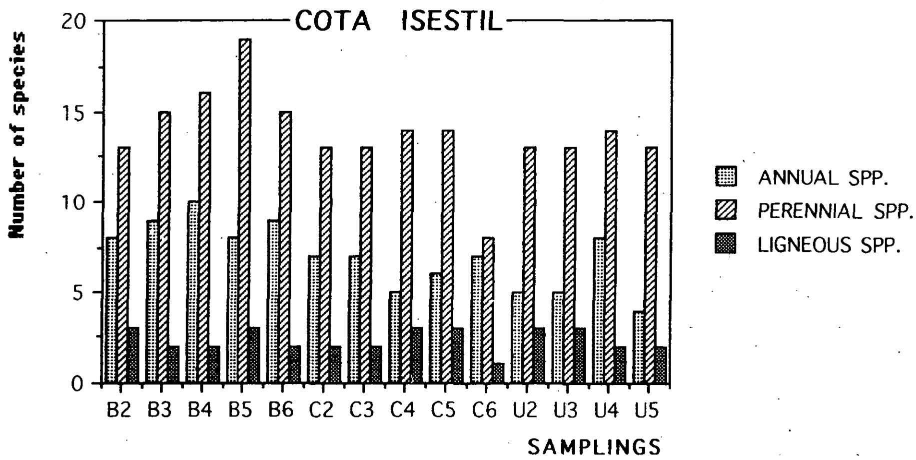


Fig. 2. Richness of different biological types in each plot and sampling period. *(Riqueza de los diferentes tipos biológicos en cada parcela y para cada período de muestreo).*

Maximum richness (Table 2) is observed in the fourth year after treatment in Majada de Setibar. In Cota Isestil maximum richness in the burnt and uprooted plots is recorded in the fifth year and, in the cut plot, the number of species remains virtually constant. In general, evenness does not vary greatly. Some studies on regeneration processes after fire in shrublands (CASAL, 1987; TRABAUD, 1987) recorded the greatest number of species

TABLE 2
Temporary variation of parameters analyzed in the experimental plots, from second until sixth year after treatments. *(Variación temporal de los parámetros analizados en las parcelas experimentales, desde el segundo hasta el sexto año después de los tratamientos).*

TOTAL VEGETAL COVER

		Sampling year				
		1987	**1988**	**1989**	**1990**	**1991**
Majada de Setibar:	Burning plot	87.8	79.8	104.6	99.4	106.0
	Cutting plot	52.0	69.2	69.8	69.2	83.0
	Uprooting plot	33.4	80.0	91.8	73.0	95.0
Cota Isestil:	Burning Plot	46.8	63.8	75.4	85.4	71.2
	Cutting Plot	39.6	59.2	78.6	53.4	88.0
	Uprooting Plot		17.2	37.2	53.4	46.8

RICHNESS

		Sampling year				
		1987	**1988**	**1989**	**1990**	**1991**
Majada de Setibar:	Burning plot	19	24	27	25	23
	Cutting plot	22	18	23	16	12
	Uprooting plot	29	28	35	29	27
Cota Isestil:	Burning Plot	24	25	28	29	26
	Cutting Plot	22	22	23	22	23
	Uprooting Plot		16	21	25	19

EVENNESS

		Sampling year				
		1987	**1988**	**1989**	**1990**	**1991**
Majada de Setibar:	Burning plot	0.67	0.64	0.67	0.62	0.57
	Cutting plot	0.71	0.68	0.61	0.62	0.63
	Uprooting plot	0.70	0.76	0.77	0.75	0.64
Cota Isestil:	Burning Plot	0.74	0.78	0.66	0.58	0.67
	Cutting Plot	0.53	0.67	0.60	0.63	0.54
	Uprooting Plot		0.88	0.74	0.59	0.70

SPATIAL HETEROGENEITY

		Sampling year				
		1987	**1988**	**1989**	**1990**	**1991**
Majada de Setibar:	Burning plot	0.55	0.69	0.52	0.60	0.75
	Cutting plot	0.55	0.34	0.17	0.25	0.32
	Uprooting plot	0.64	0.79	0.63	0.74	0.82
Cota Isestil:	Burning Plot	0.83	0.79	0.45	0.48	0.82
	Cutting Plot	0.01	0.31	0.27	0.25	0.16
	Uprooting Plot		0.98	0.54	0.30	0.35

between the first and third year after the fire, related to therophyte invasion. This is not so clear in the plots studied here, as therophyte invasion. This is not so clear in the plots studied here, as therophyte increase in the early stages is due, above all, to greater cover than to an increase in the number of annual species. Thus, greater therophyte richness occurs after two years in the cut and uprooted plots in Majada de Setibar (Fig. 2), but not in the others. There is generally a greater richness in annual species in this area, while highest number of species in Cota Isestil is recorded for herbaceous perennials.

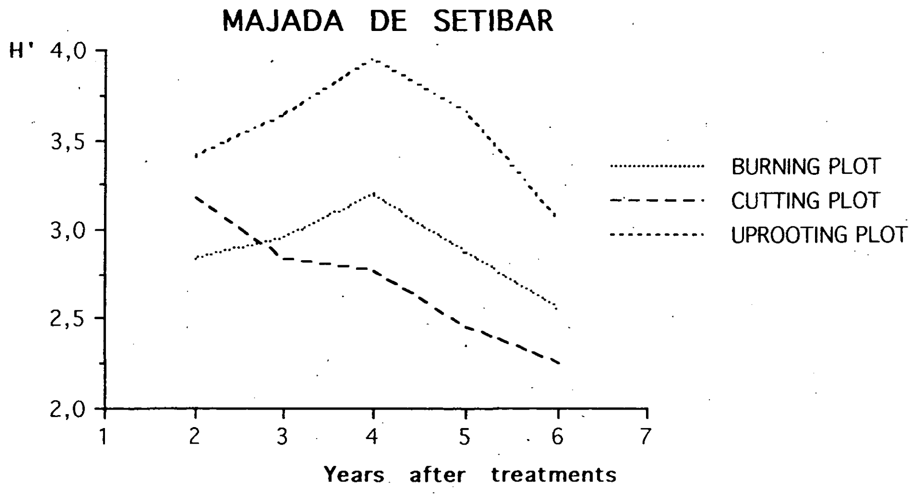
Highest diversity in Majada de Setibar is in the fourth year in the burnt and uprooted plots and in the second year in the cut plot, with a decrease in the following years (Fig. 3). Maximum diversity is observed in the three Cota Isestil plots in 1988, theree years after cutting and burning and two after uprooting.

Spatial heterogeneity (Table 2) in Cota Isestil tends to decrease with time in the three plots. There are no clear tendencies in Majada de Setibar. However, on comparing the different treatments in both areas, the highest values usually correspond to the uprooted plots and the lowest to the cut ones.

In Majada de Setibar fluctuations in temporary heterogeneity are minimal (Fig. 4). The highest values are for the interval between the second and third year in the uprooted plots in both areas, with the highest values of all those observed. The highest value in the Cota Isestil cut plot is also observed between the second and third year, whilst it is between the third and fourth year in the other plots. A comparison of the final years shows the highest values in all cases, which indicates that the most marked changes in these communities occur in the early regeneration stages. It is even likely, although not certain as there is no data, that the greatest changes in species composition occured between the first and second year after cutting and burning. Temporal heterogeneity for these plots is very low compared to that for uprooted ones. There was hardly any vegetation in these in the uprooting year (LUIS *et al.*, 1988), since regenerations is slower due to the more drastic impact. The greatest changes are observed between the second and third year.

Conclusion

A good recovery response is observed after all treatments, although it is slower in the case of uprooting, as this produces the strongest environmental degradation. As far as the cutting treatment is concerned, this does not alter environmental conditions as much as the other two. No great changes in the number of species are observed in these plots; however, they are observed in plant cover as the surface biomass of ligneous species was eliminated in the first stages and the time needed to recover is similar to that for the burnt one. Less cover is observed in the uprooted plots in the first samplings. This is due, above all, to the ligneous species, which, although appearing from the



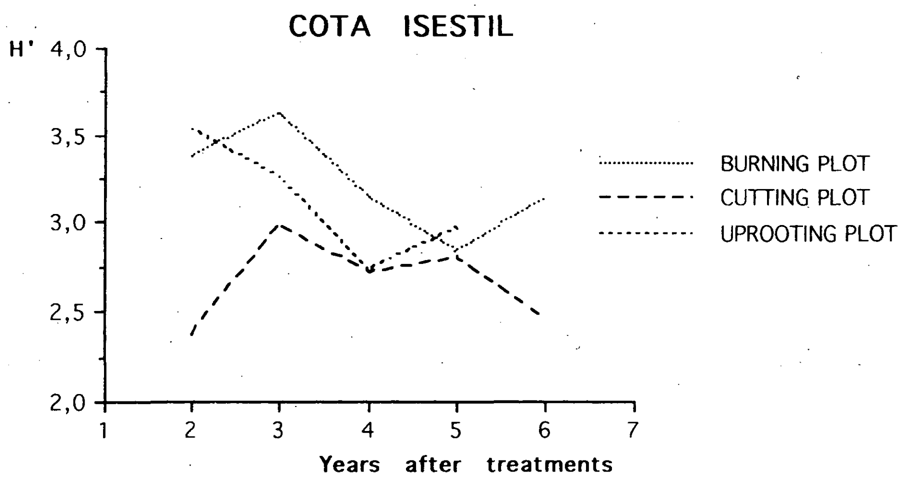
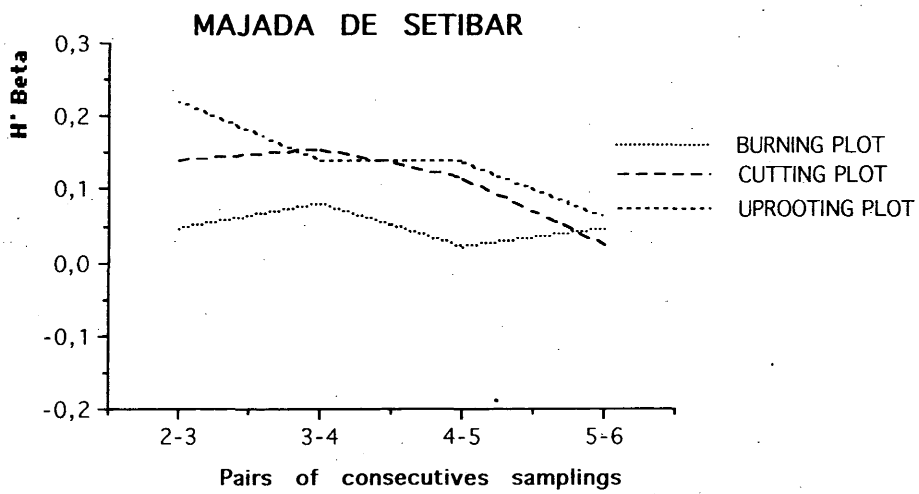


Fig. 3. Diversity values in each plot and sampling period. *(Valores de diversidad en cada parcela y para cada periodo de muestreo).*



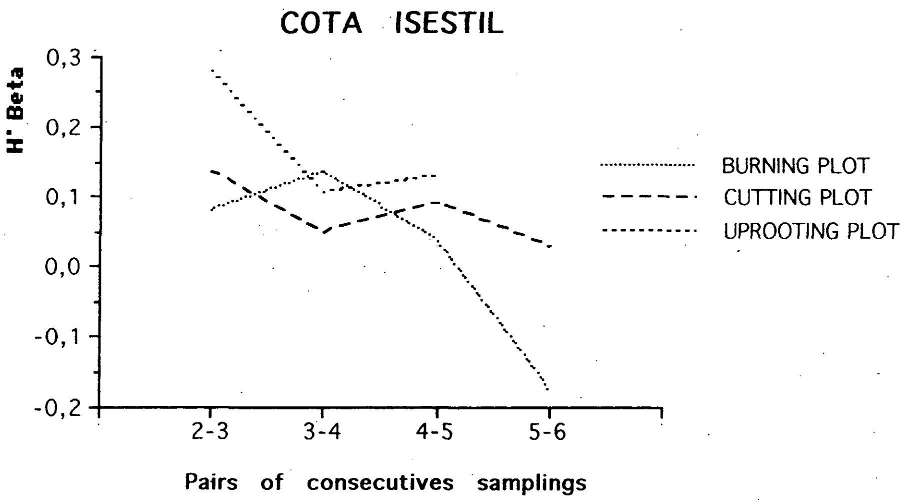


Fig. 4. Temporary heterogeneity between pairs of consecutives samplings in each plot.
(Heterogeneidad temporal entre pares de muestreos consecutivos en cada parcela).

beginning, are of much less significance than in the burnt and cut plots where they sprout in great abundance. Moreover, the latter show less spatial heterogeneity and the changes in species composition in following years are not very great, while changes after uprooting are more marked in the second and third year. In all cases these changes tend to decrease with the course of time determining almost imperceptible temporary heterogeneities.

By means of the temporary variation of diversity and its components it seems to follow that, except in the first regeneration stages, the environmental conditions in each specific year have a great influence on the values of these parameters. This could explain the high diversity recorded in 1988 in the three Cota Isestil plots, independently of the different treatments they were subjected to and the different dates on which they were carried out. Highest diversity is in the second or third year in Cota Isestil and the second or fourth years in Majada de Setibar.

Regeneration in the communities studied is an autosuccesion process, similar to that previously existing (CALVO *et al.*, 1989). This coincides with the results of most studies on secondary succession processes in Mediterranean ecosystems (TRABAUD, 1987; FERNANDEZ *et al.*, 1990; DE LILLIS & TESTI, 1990). A greater abundance of therophytes is observed two years after treatment, but these are quickly replaced in later years by species natural to the community.

In spite of the great abundance of shrub species which are predominant in most plots, comparison with the control plots, from a physiognomic point of view, shows that they have not yet completely recovered their pre-treatement characteristics. Because of this, these communities will continue to be studied in subsequent years.

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