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THE PROCESS OF DESERTION OF CULTIVATED AREAS IN THE CENTRAL SPANISH PYRENEES [1] *

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SUMMARY.—During the present century the cultivation of more than 70 % of historical farmland has been abandoned in the Aragonese Pyrenees. This paper studies the influence which different human and physical factors have had on this process of desertion. The results show that desertions in the past are fundamentally related to physical variables: geoforms, slope, altitude and exposure, whereas, the fields deserted later than 1957 are linked more to accessibility and field-type, once the last fertile land had been abandoned in the first stage of farmland reduction and in keeping with the greater importance given to the mechanization of farmwork.

RESUMEN.—El proceso de abandono del espacio cultivado en el Pirineo central español. *En el Pirineo aragonés se ha dejado de cultivar durante el presente siglo más del 70 % de su espacio agrario histórico. En este trabajo se estudia la influencia que ejercen diferentes factores físicos y humanos en el proceso de abandono. Los resultados muestran que los abandonos antiguos se relacionan fundamentalmente con variables físicas: geoformas, pendiente, altitud y exposición. Por el contrario, los campos abandonados con posterioridad a 1957 se vinculan más a la accesibilidad y a los modelos de campos, una vez que en la primera fase de contracción del espacio agrario se habían abandonado los menos fértiles y conforme la mecanización de las labores agrícolas ha adquirido mayor importancia.*

RESUME.—L'abandon de l'espace cultivé dans les Pyrénées centrales espagnoles. *Plus de 70 % de l'espace historiquement cultivé ont été abandonnés au cours de ce siècle dans les regions les plus elevées des Pyrénées aragonaises. Notre travail étudie l'influence de divers facteurs physiques et humains sur ce processus. Les abandons les plus anciens sont liés a des variables physiques: "geoformas", pente, altitude, exposition et fertilité. A l'inverse, les abandons posterieures à 1957 sont liés à l'accesibilité et aux types de champs principalement, au fur et à mesure que la mécanisation acquiert de l'importance.*

1 This project has been carried out within the Research Projects: "Ecological study of the working system of pastureland and farmland at the service of livestock in the mountain territories of Alto Aragón", Project 2515/83 of CAICYT, and "Erosion and vegetable colonization of abandoned fields" within the programme LUCDEME of ICONA.

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The most remarkable feature in the evolution of Spanish mountains is the pronounced process of desertion which a large part of its territory has undergone. For many reasons of human and livestock feeding, very large areas were cultivated, sometimes in very difficult topographical conditions. In the Burgos mountains 45 % of the area was farmed (ORTEGA VALCÁRCEL, 1974); in the Jubera Valley (Sistema Ibérico) 35 %, according to GARCÍA-RUIZ *et al* (1985), in Albarracín 18 % (CALVO PALACIOS, 1973), in the Alpujarras of Granada, 35.4 % (BOSQUE, 1968) and 82 % in the mountains of Málaga (GÓMEZ MORENO, 1985). However, as a result of changes in the population structure and evolution experienced in working systems, during recent decades an important decline in cultivated area has been noticed and consequently an increase in the number of abandoned fields. Between 1940 and 1975 about 40 % of cultivated land in the Cabrera leonesa had been abandoned (CABERO, 1980), more than half in the valleys of Asturias (RODRÍGUEZ, 1984), 89 % of the southern slopes of the Sierra de Ayllón (BORDIU, 1985), three quarters of Alto Tormes (BARRIENTOS, 1978), over 36 % in the Sierra de Ronda and 25 % in Planicie de Ronda (GÓMEZ MORENO, 1985) and 100 % of some valley of Cameros (GARCÍA RUIZ *et al*, 1985).

The Central Pyrenees are not free from this process either, as they show a desertion of over 70 % of the historical area (LASANTA, 1988). Recent evaluations carried out in several representative valleys confirm that about 16 % of the territory has been farmed, showing that deserted land occupies a large area. This proportion is greater if we include the land below 1600 m, in this case the percentage rises to an average of 28 %, in spite of huge topographical difficulties.

This spectacular and common process of abandonment has several environmental and socio-economical implications. A change in the hydrological and geomorphological functioning of the slopes takes place, and, instead of being controlled by man, they become involved in a struggle between vegetable colonization and the instalation of certain erosive processes (GARCÍA RUIZ, in press).

Nevertheless this desertion process has happened in a complicated way, particularly from a spacial point of view. A series of physical and socio-economic factors explain the tendency towards desertion in certain environments and also explain how the reduction of cultivated land has occurred. The aim of this paper is to define the relative importance of these factors in the abandonment process and to identify environmentally these marginal territories.

1. The study area

The study was carried out in the High Aragonese Pyrenees, Spain, constituting a long narrow band (see Fig. 1) which contains at present 34 towns or villages and comprises 3278 Km². In 1981 the demographic density was 4.02/Km², while in 1900 it reached 8.07/Km².

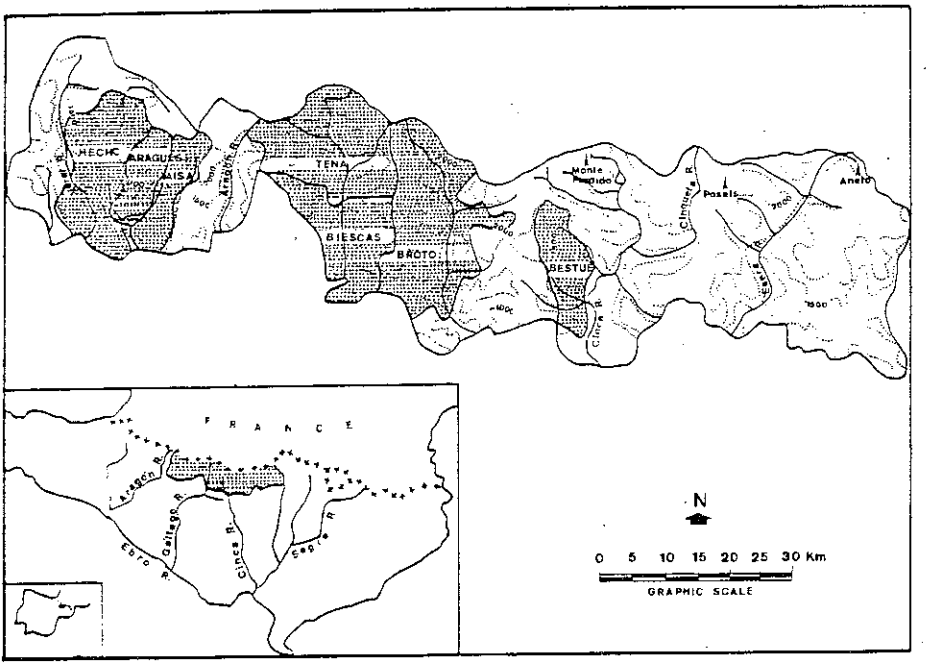

Fig. 1. — The study area *(Area de estudio).*

From a physical point of view it is worth remembering that the structure and lay-out of the lithology are arranged in more or less parallell bands from West to East. Within the study area three large bands are differentiated; from North to South these are: the Axil Pyrenees, the Inner Ranges *(Sierras Interiores),* and the Flysch Ranges. The Pirineo Axil constitutes the central hub of the mountain range and the main watershed between the Spanish and French slopes. Geologically it consists of palezoic materials of differing resistance to erosion. The Inner Ranges, of calcareous lithology, present a more homogenous relief. Both areas have hardly been used agriculturally due to their steep slopes and high altitude, whereas the Flysch ranges,

being at a lower altitude and containing milder slopes and spacious watersheds, were extensively formed for the cultivation of cereals, particularly in the sunny areas. At present the majority of these sunny areas are covered by abandoned fields which are being overtaken by scrub in different stages of plant succession (GARCÍA-RUIZ and PUIGDEFÁBREGAS, 1982).

The network of rivers flows from North to South, cutting through the structure. The breadth of the valley bottom depends on the lithological resistance. In this way we find, in certain parts of the rivers course, relatively wide depressions which are used as pastureland in high areas and for crops in lower areas; however, in other sections there are deep gorges which prevent any sort of human use and even caused in the past communication difficulties. Glacial action has helped to create areas favourable to agricultural use by enlarging some valley bottoms and by the formation of side-blocked valleys filled with glacio-lacustrine sediments.

From a climatic point of view we should consider the influence of two gradients; one of which, moving from West to East, shows a progressive transition from an oceanic mountain climate to one of a more mediterranean-continental character (CREUS, 1983). On the other hand, the height factor causes important thermic and pluviometric contrasts. It is well known that the higher the altitude the greater the rainfall, the lower the temperatures and the shorter the vegetation period. The thermal system almost totally prevents cultivation above 1500-1660 m, and natural woodland hardly appears above 2100 m.

Altitudinal-climatic grading and the duration of the vegetation period allow three levels of land use to be differentiated schematically:

—Above 1600 m the level of summer pastureland has evolved for exclusively seasonal use. This level was extended by man to increase the area of pastureland, so as to facilitate the maintenance of large numbers of livestock and to lengthen the grazing period. In the majority of the valleys this land occupies about 30 % of the total area.

—Lower down, the forestal level appears particularly in the shady areas as the sunny areas have been greatly affected by the expansion of nomadic cultivation at times of heavy demographic pressure. In the past the woodland had an agro-silvo-pastoral use but has now been reduced to timber production.

—The crop level is found in the lower parts of the valleys, although frequently this level was extended at the cost of the two higher levels, occupying flat areas on hillsides and enclaves with

relatively mild slopes. This fact involved an important expansion of the farming area as we will see later.

In the traditional system, agriculture was based on cereal cultivation, the principal function of the farmland being to provide for the population, while that of the summer pastureland fed, during the summer a large number of livestock which migrated in winter to the middle of the Depresión del Ebro (trashumance). At present the farmland is taken up by the production of fodder to feed the livestock during the winter. This development can be explained by the decrease in population, the ability to import food and the need to maintain the livestock once the trashumance has ceased. (LASANTA, 1988; GARCÍA-RUIZ and LASANTA, in press).

2. Methods

To archieve the proposed objectives a methodology based on information gathered from aerial photographs of 1957 and 1981, the National Topographical Map and complimentary work in the field was used.

Following several criteria demography, implantation of the tertiary sector and location along the studied area, seven representative zones were defined: the Valleys of Hecho, Aragüés, Aísa, Tena, Broto, Bestué-Puértolas and Ribera de Biescas. Altogether they make up almost 40 % of the High Aragonese Pyrenees. Using the aerial photograph from 1957 the area which had been cultivated was defined. In the photograph the area which was still being cultivated and that which han been abandoned could be seen. By means of the photograms of 1981 we collected information about the area abandoned between 1957 and 1981 and that still being cultivated in 1981. In this way the cultivated area could be determined at three dates and the abandoned area before and after 1957.

In the same way, and within the limits of the historical cultivated area, homogenous areas were mapped out according to geomorphological and topographical criteria. These areas were given the conventional name of geoforms. After several field trips and from aerial photography 13 types were chosen:

1. *Hanging terraces:* This term is used to describe old fluvial terraces, clearly positioned above the present river-bed and defined by an escarpment. Small fragments of lateral *glacis,* of similar behaviour to the hanging terraces, were included.

2. *Subactual fluvial valley bottoms:* These are very recent fluvial deposits, raised at merely a few metres above the present river-bed.
3. *Alluvial fans:* These appear relatively frequently at the bottom of the valley, sometimes of great size. (e.g. in the Ribera de Biescas).
4. *Footslopes:* These are the slightly concave sectors situated at the foot ot the hillside.
5. *Sideblocked valleys:* These are ledges of glaciolacustrine origin, located in valleys feeding into the ancient main valley. In the study-area the Sobremonte, at the foot of the Peña Telera, that of the Linás de Broto and that of the Reclusa in the Hecho valley, stand out, while there are many more of lesser size.
6. *Moraines:* The morainic deposits have been mapped out where signs of cultivation appear, mainly corresponding to lateral moraines.
7. *Straight hillsides:* These correspond to the usually steep sectors which are rectilinear to the hillside. This is the most widely distributed geoform in the study area, the size being variable according to the specific topography of each slope.
8. *Concave hillsides:* These are concave surfaces on the slope, normally steep but less so than in the straight hillsides.
9 *Convex hillsides and watersheds:* These are convex sectors of slopes. They almost always correspond to very slight watersheds and reliefs immiediately below them. They are particulary evident in the Flysch area.
10. *Flat hanging ledges:* These are old reliefs which have remained in mid-slope and which keep a mild topography, with a tendency towards concavity.
11. *Inclined hanging ledges:* As before these are old reliefs differing however in that they are much steeper, although always less so than the rest of the hillside on which they are situated.
12. *Flat and cradle ravines:* These are deserted valleys usually disconnected from the valley head and river's end. They usually are of an elongated shape widening slightly when they join two or more other ravines.
13. *Lober of large mass movements:* These constitute large tongues of land caused by mass movement. They do not appear very often in the study area, while in the Tena and Broto valleys we have mapped some of notable size. They are more frequent in the forestal level. (GARCÍA-RUIZ and PUIGDEFÁBREGAS, 1982).

In simple terms two large groups can be differentiated with regard to their suitability for agricultural use. The first group includes the first five geoforms, which have the more fertile soil and a flat or mildly sloping topography, and which act as fertility receivers due to their position on the hill (footslopes) or to their flat topography. In short, this first group comprises those geoforms which are considered favourable. The second group includes the other 8 geoforms, possessing less deep soil and steeper slopes. However, the last four present a greater agricultural potentiality from a physical point of view, even though, because of their small size and inaccessibility, they are not very favourable for agricultural use at present.

Therefore, the geoforms were used to identify spacially differentiated units. For each one the following information was obtained:

—*Land use in 1957 an 1981:* differentiating between cultivated fields (cereal crops and cutting meadows), abandoned fields and grazing meadows. The latter also corresponding to abandoned fields which have evolved spontaneously into meadows.

—*Exposure:* differentiating between northern (N, NW, NE), intermediate (W and E) southern (SW, S and SE) and open.

—*Slope:* discriminating between 5 categories: less than 5 % slope: from 5 % to 10 %; from 10 % to 20 %, from 20 % to 40 % and over 40 %.

—*Height:* establishing four categories: less than 900 metres; 900 m - 1200 m; 1200 m - 1500 m and over 1500 m.

—*Distance:* from the settlement which is used by the fields: Three categories: less than 1 Km; 1 - 3 Km and over 3 Km.

—*Accessibility* from the fields to the settlement which uses them, differentiating between a) units which can be reached by road or asphalt path. b) units which can be reached by an unasphalted road or a forest path which allows farm machinery to pass and c) units which are impossible to reach with farm machinery.

—*Fields models:* this refers to the topographical form of each field included in each unit. We chose four groups; flat fields, terraced fields, sloping fields and itinerant fields (or *articas).* The latther were farmed at times of heavy human pressure on the area. They were usually farmed for two or three years and then abandoned for a greater or lesser period to allow them to regain their fertility. (VIOLANT, 1949).

The statistical treatment is based on information gathered from statistics and from two Discriminating Analysis (one referring to 1957 and the other to 1981) to determine the variables which influence the

desertion or maintenance or farm land. In table 1 ten discriminating variables have been selected with values which we have attributed.

TABLE 1

Variables considered for carrying out the discriminating analyses

1. Geoforms
   -Value 0: unfavourable group
   -Value 1: favourable group

2. Exposure
   -Value 1: Northern
   -Value 2: W, E and open
   -Value 3: Southern

3. Var. open exp.
   -Value 0: Rest of exposures
   -Value 1: Open exposure

4. Slope
   -Value 1: 5 %
   -Value 2: 5-10 %
   -Value 3: 10-20 %
   -Value 4: 20-40 %
   -Value 5: above 40 %

5. Height
   -Value 1: less than 800 m.
   -Value 2: 800-1.000 m.
   -Value 3: 1.000-1.200 m.
   -Value 4: 1.200-1.400 m.
   -Value 5: above 1.400 m.

6. Distance
   -Value 1: less than 1 Km.
   -Value 2: 1-3 Km.

7. Accessibility
   -Value 0: plots with bad access
   -Value 1: plots with easy access

8. Flat field models
   -Value 0: Rest of models
   -Value 1: Flat fields

9. Sloping field models
   -Value 0: Rest of models
   -Value 1: Sloping fields

10. Terraced field models
    -Value 0: Rest of models
    -Value 1: Terraced fields

3. Features of the historic farmland

From the 1957 aerial photography it can be seen that almost 16 % of the Pyreneean territory was used as farmland in the past. If we consider exclusively the surface below 1600 m (which can be considered potentially farmable) the area worked exceeds 28 % for the total sampled area, fluctuating between 22 % and 33 % among the diferent valleys considered (see table 2).

The largeness of the expanse covered by farmland in an unfavourable environment implies that man had to cultivate a very heterogeneous area, frequently using enclaves unsuitable for farming. The study of the distribution of farmland according to different parameters helps us to explain its features.

Table 3 shows the greater area occupied by geoforms with less possibilities for cultivation (especially straight, concave and convex hillsides). Logically man used the least suitable geoforms when better

ones were not available. Thus, in Ribera de Biescas, which contains flat areas of lateral obturation and valley bottoms, the occupation of hillsides for farm use was much more modest.

TABLE 2

Maximum cultivated area in several pyrenean valleys

Valley	Total area (Ha)	Area below 1.600 m (Ha)	Cultivated area (Ha)	% reference to total	Reference to surface 1.600 m below
Hecho	23.375	19.503	5.886	25,18	30,18
Aragüés	7.349	5.154	1.139	15,50	22,10
Aisa	8.154	4.728	1.551	19,02	32,80
Tena.....	30.101	6.147	1.703	5,66	27,70
Biescas	18.630	15.220	3.713	19,93	24,39
Broto	31.420	15.078	4.653	14,81	30,86
Bestué.....	9.986	7.224	1.884	18,87	26,09
Total	129.015	73.054	20.507	15,89	28,07

TABLE 3

Distribution of the cultivated surface according to the geoforms (in %)

Geoforms	Hecho	Aragüés	Aísa	Tena	Biescas	Broto	Bestué	Pirineo
Terraces.....	3,04	5,96	7,31	3,60	0,32	1,16	10,26	3,0
Valley bottoms	5,13	1,27	2,62	1,17	5,29	1,64	2,08	3,3
Alluvial fans	3,10	2,86	1,42	5,11	7,64	5,60	0,83	4,6
Footslopes	5,94	11,89	4,62	6,09	4,78	5,07	3,19	5,3
Sidebocked valleys	1,30	0,23	1,23	—	31,66	2,95	0,68	8,6
Moraines	0,49	—	—	0,58	4,23	1,08	0,67	1,4
Straight hills.	52,56	36,59	51,16	29,31	20,72	58,95	38,72	43,0
Concave hills.....	6,34	13,66	13,70	11,71	2,78	6,16	17,69	7,7
Convex hills.....	16,67	15,98	12,13	12,14	5,30	11,92	24,24	12,1
Flat hanging ledges.....	2,22	1,07	1,42	16,21	15,18	1,66	2,46	6,2
Inclined hanging ledges...	1,13	3,71	0,98	3,02	1,63	3,37	2,65	2,2
Flat ravines	2,10	6,78	3,26	4,43	0,05	0,12	0,5	1,5
Lobes of mass movements	—	—	0,09	6,64	0,35	0,31	—	0,72

Table 4 shows that 54 % of the farmland was on slopes of over 20 %, exceeding therefore the limit considered suitable for cultivation. Above such a level cultivation causes serious problems of erosion, with a consequent rapid loss of soil. On the other hand, the flat or mildy sloping area comprises only 22.5 % of the farmed area, Biescas

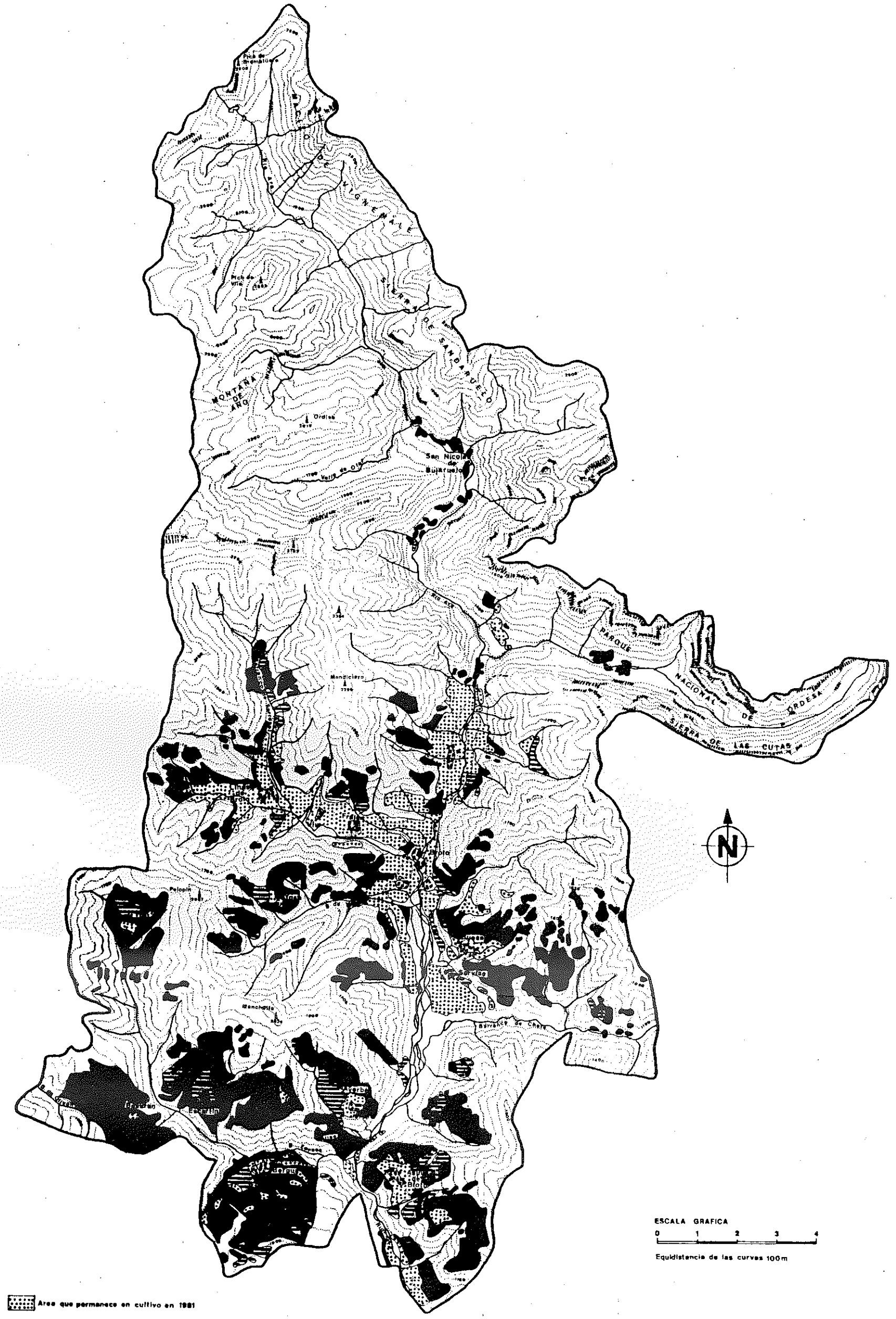

Fig. 2. — Evolution of the cultivated area in the Broto Valley. *(Evolución de la superficie cultivada en el Valle de Broto).*

geological structure from North to South, favouring the existence of predominantly Western and Eastern hillsides. In table 4 a great concentration of farmland between 900 m and 1500 m can also be seen, with sharp declines below and above this altitude. The former is due to the scarcity of fields below 900 m; in fact, only 15.11 % of the area studied came below 1000 m (LASANTA, 1988). The latter involving important ecological limitations in some crops due to the short vegetative period. Nevertheless, 2.6 % of the farmland was above the 1500 m limit, even reaching 1900 m with the cultivation of rye in 13 month cycles in the so-called *panares* (DAUMAS, 1976).

The distribution of the farmland by field models, (see Table 5) shows that the flat and mildly sloping land occupied only 22.5 % of the total, while in the remaining area less suitable models were occupied. In fact almost 23 % was taken up by *articas,* that is, sporadic fields formed on very steep hillsides with high stanyness and little soil. However, important differences can be seen between the western sector (first three valleys) and the eastern sector (last two valleys). In the former the sloping fields and *articas* predominate, while in the latter the terraced fields occupy the greater area. This is as much due to the difference in rainfall as the existence in the past of two cultures which considered the land from radically different points of view (BALCELLS, 1976; PUIGDEFÁBREGAS, 1981). The Tena and Biescas valleys constitute areas of transition containing influences from both tendencies.

4. Features of the abandoned farmland

The preceeding pages have tried to emphasize the wide area covered by farmland in a mountain enviroment such as the pyrenean. The main aim of this area was to guarantee a system of autosufficiency in which the basic alimentary needs were assured (LASANTA, 1988). To acheive this, almost all the sunny hillsides which were destined for the production of cereal crops were farmed in fields of greatly varied features. As the human pressure on the area diminished and the Pyrenees entered a more dynamic and wider market, autosufficiency became unnescessary. Moreover, in a competitive system, such as appeared in the sixties, there is a tendency to raise production by work investment. For this reason, the pyrenean inhabitants intensified the use of the better areas (valley bottoms, plains of lateral obturation, levels of accumulation, etc.) and extensified the use of the remaining area. The first reaction, therefore, was to stop farming all those fields which required hard work for little productivity. Only accessible areas of

flat or mildy sloping topography (easily mechanized) continued to be farmed, while the rest were abandoned. In figure 2, which is representative of the whole area studied, it can be seen that cultivation of only the valley bottoms and the area surrounding the populations has been kept up. In 1957, 63.25 % of the farmland had been abandoned and in 1981, 70.28 % (LASANTA, 1988).

In table 6 the evolution experienced by the geoforms in the favourable group and the unfavourable group can be compared. The former continue to be farmed in a high proportion both in 1957 and 1981. Nevertheless, the footslopes show a slightly higher percentage of desertion, as a result of the slopes which possess this geoform in some enclaves. In 1957 most of the unfavourable geoforms lost over 60 % of the historical farming area, with the massive desertion of the straight, concave and convex hillsides which were the most obvious exporters of fertility.

In a study of several features of cultivated soil on convex, plain, and straight hillsides and footslopes it was shown that the convex and straight hillsides lost oligoelements while the plains and footslopes accumulated fine sediments, organic matter, nitrogen and calcium. The

TABLE 6

Distribution of the historical agrarian space according to the different geoforms (1957 and 1981)

		1957				1981			
	Historic. surface	Cultivated space		Abandoned space		Cultivated space		Abandoned space	
	Ha.	Ha.	%	Ha.	%	Ha.	%	Ha.	%
Terraces	615	541	87,97	74	12,03	538	87,48	77	12,52
Flat valley bottoms	681	595	87,37	85	12,63	571	83,85	108	16,15
Alluvial fans	956	821	85,88	135	14,12	805	84,21	149	15,79
Footslopes	1.103	773	70,08	331	29,92	641	58,11	464	41,89
Sideblocked valleys	1.780	1.753	98,48	28	1,52	1.768	99,33	13	0,67
Moraines	303	242	79,87	63	20,13	225	74,26	78	25,74
Straight hillsides	8.830	1.081	12,24	7.747	87,76	505	5,72	8.326	94,28
Concave hillsides	1.581	397	25,11	1.185	74,89	209	13,22	1.371	86,78
Convex hillsides	2.490	275	11,04	2.215	88,96	135	5,42	2.355	94,58
Flat hanging ledges	1.266	478	37,76	788	62,24	328	25,91	938	74,09
Inclined hanging led.	447	289	64,65	158	35,35	163	36,47	284	63,53
Flat ravines	308	234	75,97	74	24,03	178	57,79	130	42,21
Lobes of mass movements	147	60	40,82	87	59,18	29	19,73	118	80,27
Total	20.507	7.539	36,75	12.970	63,25	6.095	29,72	14.411	70,28

evolution of phosphorus and potassium was more difficult to follow because of the particular behaviour of these nutrients in the soil and because of the presence of chemical fertilizer added by the farmer, although a slight tendency towards concentration appeared on the flat areas and very clearly on the footslopes. However, the Total Change Capacity, tends to be greater at the foot of the hillside (LASANTA, 1988).

Much smaller percentages of desertion were shown in moraines, inclined hanging ledges and valley bottoms, due to the higher quality and potentiality of the soil. It should be noted that the flat hanging ledges had a greater proportion of abandoned land that the inclined hanging ledges, explained by the lesser average area in the former unit. In 1981 both the flat ravines and the inclined hanging ledges had already experienced extensive desertion because of their inaccessibility as well as their being disconnected from the principal communication network (LASANTA, 1988), while cultivation of the moraines has largely been kept up (74.26 %) due to their suitability for meodowland (MONTSERRAT, 1988).

TABLE 7

Distribution of the historical agrarian space according to topographical factors in 1957 and 1981

		1957				1981			
	Historic. surface	Cultivated space		Abandoned space		Cultivated space		Abandoned space	
Exposures	Ha.	Ha.	%	Ha.	%	Ha.	%	Ha.	%
Northern	2.805	870	31,02	1.937	69,00	573	20,40	2.233	79,61
Intermediate	5.877	2.571	43,75	3.305	56,25	2.110	23,90	3.768	64,10
Southern	10.752	3.260	30,32	7.491	69,68	2.597	24,15	8.157	75,85
Open.....	1.073	837	78	237	22	812	75,68	262	24,32
Slopes									
—5 %	3.105	2.981	96	123	4	2.982	96,04	121	3,96
5-10 %	1.511	729	48,25	783	51,75	640	42,36	872	57,74
10-20 %	4.811	2.248	46,75	2.562	53,25	1.687	35,07	3.125	64,96
20-40 %	9.353	1.550	16,57	7.803	83,43	777	8,31	8.576	91,69
+40 %	1.727	32	1,85	1.697	98,15	9	0,52	1.719	99,48
Altitudes									
—900 m.	3.228	1.874	58,05	1.354	41,95	1.660	51,42	1.568	44,58
900-1.200 m.	7.614	2.589	34	5.026	66	1.964	25,79	5.649	74,21
1.200-1.500 m.	9.117	2.991	32,81	6.126	67,19	2.450	26,87	6.666	73,13
+1.500 m.	548	85	15,51	463	84,49	18	3,28	530	96,72

The upkeep of farming in the geoforms of flat topography explains why open exposure registers very little abandoned area (24.32 %) while coinciding both variables spacially. However, the other exposures show higher percentages; in 1981, in fact, 79.61 % of the northerly exposed

TABLE 8

Distribution of the historical agrarian space according to field patterns in 1957 and in 1981

	1957					1981			
	Historic. surface	Cultivated space		Abandoned space		Cultivated space		Abandoned space	
	Ha.	Ha.	%	Ha.	%	Ha.	%	Ha.	%
Flat fields	4.612	4.133	89,61	479	10,39	3.975	86,19	637	13,81
Terraced fields	7.462	2.052	27,50	5.406	72,5	1.256	16,83	6.204	83,17
Sloping fields	3.761	1.315	34,96	2.450	65,04	858	22,81	2.903	77,19
"Articas"	4.673	39	0,83	4.633	99,17	4	0,09	4.669	99,91

TABLE 9

Distribution of the historical agrarian space according to the distance and accessibility to the villages (1957 and 1981)

	1957					1981			
	Historic. surface	Cultivated space		Abandoned space		Cultivated space		Abandoned space	
	Ha.	Ha.	%	Ha.	%	Ha.	%	Ha.	%
Distance									
—1 Km.	8.199	5.230	63,79	2.964	36,21	4.794	58,47	3.405	41,53
1-3 Km.	9.509	1.858	19,54	7.654	80,46	1.082	11,38	8.426	88,62
+3 Km.	2.799	450	16,08	2.344	83,92	217	7,75	2.582	92,25
Accessibility									
Asphalted road	4.550	3.821	84,16	718	15,84	3.643	84,24	896	15,76
Unasphalted road	7.825	3.080	39,36	4.746	60,64	2.402	30,70	5.424	69,3
No road	8.141	638	7,84	7.505	92,16	48	0,59	8.093	99,41

farmland had been abandoned, 75.85 % of the southerly and 64.11 % of the intermediate. Logically the hillsides with the steeper slopes were the most affected by the process of desertion. In table 7 it can be seen that the steeper the slope the higher the percentage. At a gradient of over 20 %, where mechanization is impossible, 93 % of the original

farmland has been abandoned, leaving only an occasional isolated allotment worked manually; the flat areas scarcely showing losses. However, it should be noted the 57.74 % of the area of between 5 and 10 % gradient has been abandoned; this would appear to be linked to others factors such as accessibility, altitude, distance, etc. The pattems of abandonment with regard to the altitudinal parameter show clearly that the fields at higher altitudes are the most deserted, while lower down the hillsides there is more farming. The fields on the steepest slopes and the highest ground and those with northerly and southerly exposures are those which have been abandoned most.

The desertion with respect to field models has been particularly important in the terraced fields, in sloping fields and in the *articas* (see table 8); the latter having already been abandoned in 1957, while the first two —particularly the sloping fields— still retained a large proportion of farmland. In 1981 only the flat fields and those of very slight slope were still being farmed; the terraced ones have continued being abandoned due to difficulties in their mechanization. The distance factor influences the desertion process quite remarkably, as can be seen in Table 9. Both in 1957 and 1981 the fields nearest to the villages show a relatively low percentage of desertion, sharply increasing with the distance; in 1981 not even 8 % of the areas in a radius of over 3 Km from the nucleus were being farmed. And lastly, accessibility is also a determining factor (see Table 9), in that the majority of fields which do not possess sufficient access for machinery have been abandoned, whereas, those that have an asphalt road are widely cultivated.

5. Discussion

In the preceding pages we have seen how different factors individually infuence the process of desertion in farmland in the Central Spanish Pyrenees. However, we do not know the importance of the factors in relation to each other. To acheive this we carried out two Discriminatory Analyses, considering the uses of the soil and the variables mentioned in the section on method.

Table 10 shows that, both in 1957 and in 1981, 100 % of the variation is explained by three discriminatory functions, with a very high signification level. The first function, which holds over 83 % on the two dates, separates the abandoned fields from the rest of the uses. In Table II it can be seen that only the abandoned fields have a positive sign, while the meadow and cereal land have a negative sign. Nevertheless, the grazing meadows have a lower value, indicating an intermediate

TABLE 10

Results of the discriminatory analysis for land of 1957 and 1981

Discriminatory Function	Relative %		Correlation		Signification level	
	1957	1981	1957	1981	1957	1981
1	83,43	85,65	0,67080	0,6994	0,0000	0,0000
2	10,25	11,53	0,30220	0,3380	0,0000	0,0000
3	6,32	2,82	0,24150	0,1748	0,0001	0,1475

position between the cultivated area and the worst of the abandoned area. In fact, in the second function the grazing meadows are differentiated from the rest of the uses which appear with a negative sign. The third function differentiates the cereal land from the cutting meadows, from which it matches the conditions in which each crop appears within the farming area.

In figure 3 and in Table 12 it can be seen that in 1957 the area farmed was mainly related to accessibility, with no differentiation among the field types, although the highest value (—0.313) corresponded to the sloping fields. On the other hand, the abandoned area was linked to the slope, to exposure and to a lesser extent, to distance. The pastureland were closely linked to altitude and to a lesser degree to the type of fields on the slope, to distance and to accessibility. Going into greater detail, for which Table 13 and its equivalents in Table 1 can be used, it can be shown that the abandoned fields appear preferably on slopes of over 20 % (value 4.02), in the unfavourable group of geoforms (value 0.0984), in relatively remote areas (value 1.95) and in preferably

TABLE 11

Distribution of the group in the discriminatory function of land uses in 1957 and 1981

Groups	Centroides					
	1		2		3	
	1957	1981	1957	1981	1957	1981
Cereals.....	—0,908	—2,018	—0,253	—0,485	—0,334	—1,392
Cutting meadows	—1,661	—1,595	—0,088	—0,231	0,567	0,118
Grazing meadows	—0,785	—0,603	1,118	1,039	—0,176	—0,037
Abandoned fields.....	0,706	0,666	—0,016	—0,072	0,046	—0,003

TABLE 12

Standart coefficients of discriminatory function as a result of land uses in 1957 and 1981

Variables	Coeficients					
	1		2		3	
	1957	1981	1957	1981	1957	1981
Geoform	—0,232	—0,321	—0,159	—0,105	—0,123	—0,106
Exposure	0,214	0,168	—0,171	—0,378	0,165	—0,121
Open exposure	—0,041	0,005	0,063	—0,049	0,523	0,606
Slope	0,418	0,319	—0,173	—0,094	—0,248	0,358
Altitude	—0,067	—0,109	0,859	0,571	0,357	0,498
Distance	0,147	0,246	0,324	0,445	—0,204	—0,267
Accessibility	—0,534	—0,621	0,321	0,137	0,007	0,199
Terraced fields	—0,244	—0,014	0,032	0,164	—0,399	0,292
Flat fields	—0,313	—0,284	—0,136	0,001	—0,175	0,037
Sloping fields	—0,336	—0,127	0,332	0,689	—0,775	—0,156

sunny spots (value 2.46). The desertion of this last type of exposure is due to the cultivation of hillsides particulary unsuitable because of steepness, and scarce fertility, but thermically very favourable for the production of cereals. The rapid deterioration of many of these hillsides and the loss of interest in cereals in the pyrenean economy explain their abandonment. In the French Pyrenees the sunny areas also comprise the greater area of deserted fields (PÉREZ CHACÓN and VABRE 1987 and 1988). Therefore, the abandoned fields are concentrated

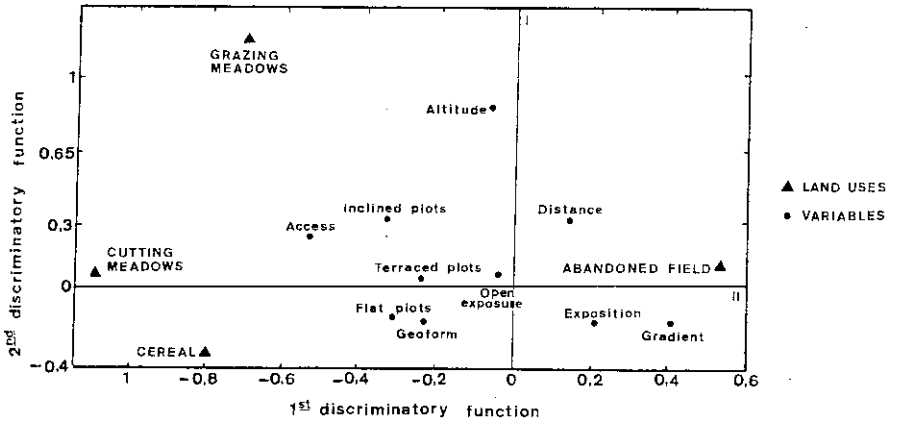

Fig. 3. — Weight of the variables considered in land uses of 1957, according to the 1 st and 2nd functions. *(Peso de las variables consideradas en los usos del suelo de 1957, según la primera y segunda funciones).*

TABLE 13

Average values of discriminatory variables in the historical agrarian space (1957 and 1981)

	Cereals		Cutting meadows		Grazing meadows		Abandoned fields	
	1957	1981	1957	1981	1957	1981	1957	1981
Geoform.....	0,4029	0,6667	0,4687	0,4817	0,2619	0,2857	0,0984	0,1068
Exposure	2,1151	2,2222	2,0781	2,1168	2,0000	1,9365	2,4601	2,4369
Open exposure....	0,0360	1,0000	0,1562	0,9089	0,0238	0,0952	0,0159	0,0941
Slope	3,3022	2,4444	2,7187	2,9854	3,4048	3,4603	4,0213	3,9782
Altitude	2,7842	1,8889	3,0469	2,9343	4,0238	3,6984	3,4122	3,3544
Distance.....	1,6691	1,6667	1,4687	1,4453	1,9524	2,0159	1,9468	1,9417
Accessibility	0,7626	1,0000	0,9687	0,9708	0,7619	0,6984	0,2819	0,2913
Terraced fields	0,3597	0,0000	0,3750	0,3796	0,3809	0,3016	0,3883	0,4005
Flat fields.....	0,2518	0,5556	0,4375	0,3723	0,1191	0,1270	0,0479	0,0534
Sloping fields	0,3885	0,4444	0,1875	0,2482	0,5000	0,5556	0,2314	0,2452

mainly in the altitudinal band between 1000 m and 1200 m. Above this level it can be stated that the greatest influences in the first stage of farmland reduction, which correspond to the abandonments before 1957, were pysical factors (topography and geoforms). The "anthopic" variables (fields types and accesibility) are secondary.

In 1981 (see figure 4 and Table 12) many of the tendencies noted in 1957 are confirmed, as the recent desertions comprise a relatively small area with respect to the whole abandoned area. Thus, the slope,

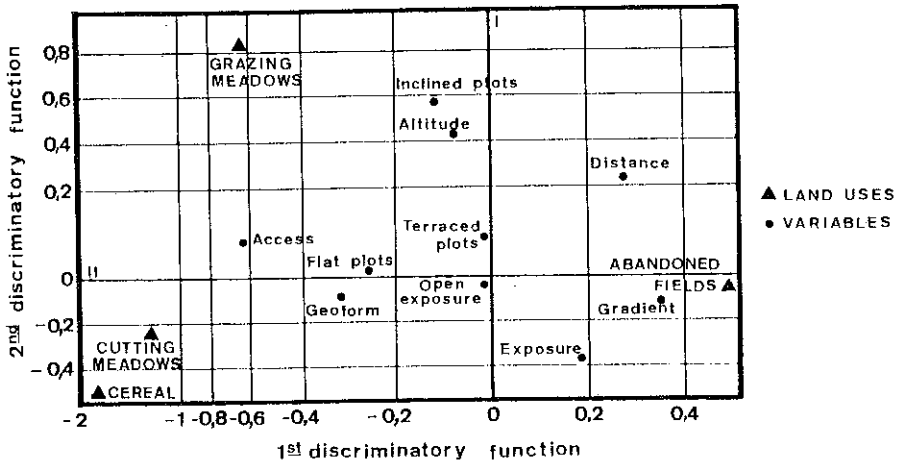

Fig. 4. — Weight of the variables considered in the land uses (1981), according to the first and second discriminatory functions. *(Peso de las variables consideradas en los usos del suelo (1981), según la primera y segunda funciones discriminantes).*

exposure, distance and geoform variables are still important. However, other variables such as accessibility and field type reach a higher level of importance. In fact, accessibility has the highest value of all (— 0.621), as this has been the essential factor in separating the farmland from the deserted land since the sixties. If we look at Table 13 we can see that cereals were only maintained in accessible fields (value 1), just as the majority of the meadows (value 0.97), while the abandoned fields and the pastureland appear in enclaves with difficult access (value 0.29). The field type also exercises a great influence, as none of the fields devoted to the cereal cultivation were on terraced hillsides, while desertion of neither flat fields (value 0.05), nor open exposure (value 0.09) is hardly noticeable, both variables normally coinciding. The abandonment of inaccessible fields and the terraced fields shows the importance of machinery in all types of farming. Only the areas accessible to machinery are still farmed, while the rest has been abandoned, farm use being uncompetitive and requiring man-power no longer available in the Pyrenees (HIGUERAS *et al,* 1985). As for the geoforms used for each use of the soil, it can be clearly that the abandoned fields appear in the least favourable (value 0.11), while the best have been reserved for cereals (value 0.67) which is at present the most selective farming in the Pyrenees (LASANTA, 1988).

Therefore, definitively, in the process of farmland desertion the "antropic" variables exercise a greater influence in recent abandonment while the physical variables were more importan in the first phase of farmland reduction. The structures created by man to condition the least fertile hillsides and the remote areas were functional until the sixties, when the use of the land was based on abundant man-power and a system which did not compete with the exterior, but which do not work nowadays due to the expansion of an exchange market and a drastic change in the demographic structure (ANGLADA *et al,* 1980). Moreover, some of the traditional structures, such as the terracing of hillsides because of the narrowness of the terraces, creating areas far too divided up, encourage desertion even more.

6. Conclusions

Throughout this paper we have shown the characteristic features of the historical farmland, as well as the topographic conditions of relief and accessibility which the desert area contains. The cultivated area was subjected to stages of expansión and contraction, according to the human alimentary needs at any given moment. Schematically we can

talk of "stable" farmland, and other areas of "reserve farmland" which have been used at times of greater demographic pressure or at times of subsistence crises (GÓMEZ URDAÑEZ, 1986). Throughout the 20th century we have seen a progresive reduction of the cultivated area, which has affected over 70 % of the original farmland. At present no more than 9 % of the total surface is cultivated in any of the studied valleys, the majority containing between 3 % and 5 %, whereas at the beginning of this century the average extension was about 16 % of the territory (see Table 2). It should be noted, therefore, that from a landscape point of view, agriculture is a marginal activity, while the abandoned area is of a much greater environmental and socio-economical importance.
PIRINE39

The desertion patterns are closely related to the productive heterogeneity of the territory and to its capacity for adaptation to the present system of use, based on a populational structure which is scarce and elderly and the overall importance of mechanizing all farm work. Which is why, in a first stage of desertion the least fertile areas were abandoned (the steepest, the highest, etc.), while in the second stage the most difficult ones were abandoned (the least accessible and least suitable for machinery: the terraced ones for example). Once again it is shown that man's use of land is dynamic and that the structures created for certain working systems should evolve parrallel to that system. If not, a part of the land becomes useless in the new socio-economic order.

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