

Shrub responses to experimental fire. First phases of regeneration.

E. LUIS-CALABUIG*

SUMMARY - *This study is devoted to the knowledge of the regeneration of shrub vegetation community after the impact of fire. Four zones have been controlled, and they are situated in the Leon province, in the north-west of Spain, between the border of influence of the evergreen-oak tree and a typical shrubland of heath in mountain region. In each of the study zones one sampling plot of 100m² was burned, after their structural composition had been evaluated by means of an analysis of their cover. Another plot which was totally cleared by cutting was used to evaluate the biomass of the different species. The first phases of regeneration of the most important species have been evaluated subsequently. The volume has been estimated, utilizing two models of approximation, which answer to the geometrical figure of half of one ellipsoid and the paraboloid of revolution.*

KEYWORDS : *Shrub, experimental fire, regeneration, vegetation cover, heaths.*

INTRODUCTION

The Advisory Commission of Spanish Technical and Scientific Research (CAICYT) during the last few years has promoted some Special Programmes and Mobilization Plans with the aim of orientating research towards priority areas or towards those insufficiently covered. The special programme of Research and Development (I + D) in Agroenergetics was decided in 1982 in reply to the energy crisis of the Seventies and began in July 1984. One of the aims is the evaluation of the potential energy of the conventional and alternative sources of the biomass. The work we present is part of that programme, having as its primary aim the evaluation of the biomass in the forms of shrub in the Spanish region of Castilla - Leon. One part of this study is devoted to the knowledge of the regeneration of the vegetation community after the impact of several degenerative and drastic processes such as rooting up, cutting or fire. This communication will be centred on the effects of the latter.

The superficies of land covered with shrub in Spain in any of its types is about 20%, corresponding to the climax communities in the supraforestral border, extended to lower altitudes because of the elimination of the forest and the effects of abusive sheep grazing or else as parts of derived regressive formations, due to the degradation of arboreal climax.

The characteristics of shrubby formations of Mediterranean climates which are adapted to more or less periodical fires, are numerous, and in some instances they even depend on fires to maintain themselves in optimal conditions of structure and functioning. The Californian chaparral (BISWELL 1974, PARSONS 1976, KEELEY & KEELEY 1981) and the garrigues in France (TRABAUD 1980, TRABAUD & LEPART 1980), in Israel (NAVEH 1974) and in Greece (PAPANASTASIS 1977, 1978), are some of the examples. In Spain, heath and Cistus form degraded communities with a good response to fire, either due to sprouts as in the case of the heath (Erica) or to seeds as in the rockroses (Cistus).

*Departamento de Ecología, Facultad de Biología, Universidad de Leon, Campus de Vegazana, 24071 LEON, Spain.

Table I.- Average and total cover values of the shrub found before burning.

San Isidro woodland

Date of sampling JUN 1985

Date of burning MAY 1986

	n	\bar{x}	∇	\bar{X}
Genista scorpius	60	23.3	19.1	13.9
Rosa sp.	13	8.8	5.1	1.1
Halimium umbellatum	7	2.7	1.5	0.1
Crataegus monogyna	6	18.3	11.0	1.0
Quercus rotundifolia	2	10.5	9.5	0.2
Dorycnium pentaphyllum	1	15.0	-	0.1

Cota Isestil scrub

Date of sampling JUL 1985

Date of burning JUL 1985

	n	\bar{x}	∇	\bar{X}
Erica australis	100	78.6	25.5	78.6
Calluna vulgaris	2	10.0	0.0	0.2
Halimium alyssoides	1	10.0	-	0.1

Majada of Setibar scrub

Date of sampling JUL 1985

Date of burning JUL 1985

	n	\bar{x}	∇	\bar{X}
Erica australis	89	35.2	23.2	31.4
Calluna vulgaris	85	25.2	17.7	21.4
Erica umbellata	70	25.1	13.7	17.6
Arctostaphylos uva-ursi	67	65.0	30.5	43.5
Halimium alyssoides	53	6.8	5.9	3.6
Quercus pyrenaica	34	11.5	8.2	3.9
Halimium umbellatum	7	2.8	1.0	0.2

San Isidro sky station

Date of sampling JUL 1985

Date of burning JUL 1986

	n	\bar{x}	∇	\bar{X}
Calluna vulgaris	100	86.6	10.5	86.7
Vaccinium myrtillus	98	2.5	1.4	2.4
Daboecia cantabrica	8	10.0	5.0	0.8
Erica australis	7	29.2	22.9	2.0

In any case they can be considered as processes of autosuccession (GRANADOS et al. 1986) because of the rapidity with which the structure and the floristic composition recover. In the Northwest of Spain similar responses can be observed for the Ulex communities and Erica - Ulex communities (CASAL et al. 1984).

MATERIAL AND METHOD

DESCRIPTION OF THE ZONES OF STUDY

Four zones have been observed. The San Isidro woodland is situated to the north of the city of Leon, in the bordering zone of influence of the evergreen-oak grove forming a type of community characteristic of the regressive state of that arboreous dominant. Its altitude is of about 800 m. Genista scorpius and Halimium umbellatum appear as the characteristic species, accompanied by Rosa sp. and Crataegus monogyna, typical of the border of the forest, and Dorycnium pentaphyllum as nitrophilous indicator.

Near to the mountain area are situated two other zones of study. One of them, (known as Cota Isestil scrub) next to the small village of Palacios de Rueda at an altitude of 1000 m above sea level, could be phytosociologically considered as a variant of the Arctostaphylo crasifoliae-Ericetum aragonensis community, in which Erica australis subsp. aragonensis of great size appears as the dominant accompanied by Lavandula stoechas subsp. pedunculata, Halimium alyssoides, Thymus zygis, Erica umbellata and Calluna vulgaris, with a very scarce representation of all of them. It is found on very degraded marly soil within the climatic dominion of the oak tree. In this same climatic dominion and only 5 Kms away from the former is Majada of Setibar scrub, at an altitude of 1150 m. It is different from the previous one because Erica australis subsp. aragonensis, Erica umbellata, Calluna vulgaris and Arctostaphylos uva-ursi have a significative representation. They are accompanied by Chamaespartium tridentatum and Halimium alyssoides. The sprouts of Quercus pyrenaica show a lesser degree of regression.

The fourth zone of study is situated in the San Isidro sky station, completely in the mountainous region at an altitude of about 1600 m. It is a typical shrubland of heath, very humid, and is characterized by the presence of Daboecia cantabrica, Erica australis subsp. aragonensis and Calluna vulgaris, accompanied by Vaccinium myrtillus and Cytisus scoparius, all of them with a height under 50 cm and with a very homogeneous tapestry pattern cover. Phytosociologically it is included in the Daboecio - Ericetum aragonensis - Cytisetosum scoparii community.

SAMPLING

Four sample plots of about 100 m² were defined in each of the study areas in the zone of shrub possessing the most homogeneous characteristics. One of them was left as a witness and the other three received different treatments after their structural composition had been evaluated, by means of an analysis of their cover in terms of their vertical projection over the ground, characterized independently in units of 1 m². The plot which was totally cleared by cutting was used to evaluate the biomass of the different species by means of fresh weighings immediately after each cutting. Other plots were burnt and the regeneration of the different species was evaluated at posterior dates, using various methods depending on the characteristics of the vegetation and the evolution of its growth. For those plots and for the species where the size of the sprouts was appreciable each of the plants was evaluated separately. Three conventional measurements were taken (height, maximum distances in the axis N - S and in the perpendicular). The volume was estimated with these measurements involving two models of approximation (half of one ellipsoid and paraboloid of revolution).

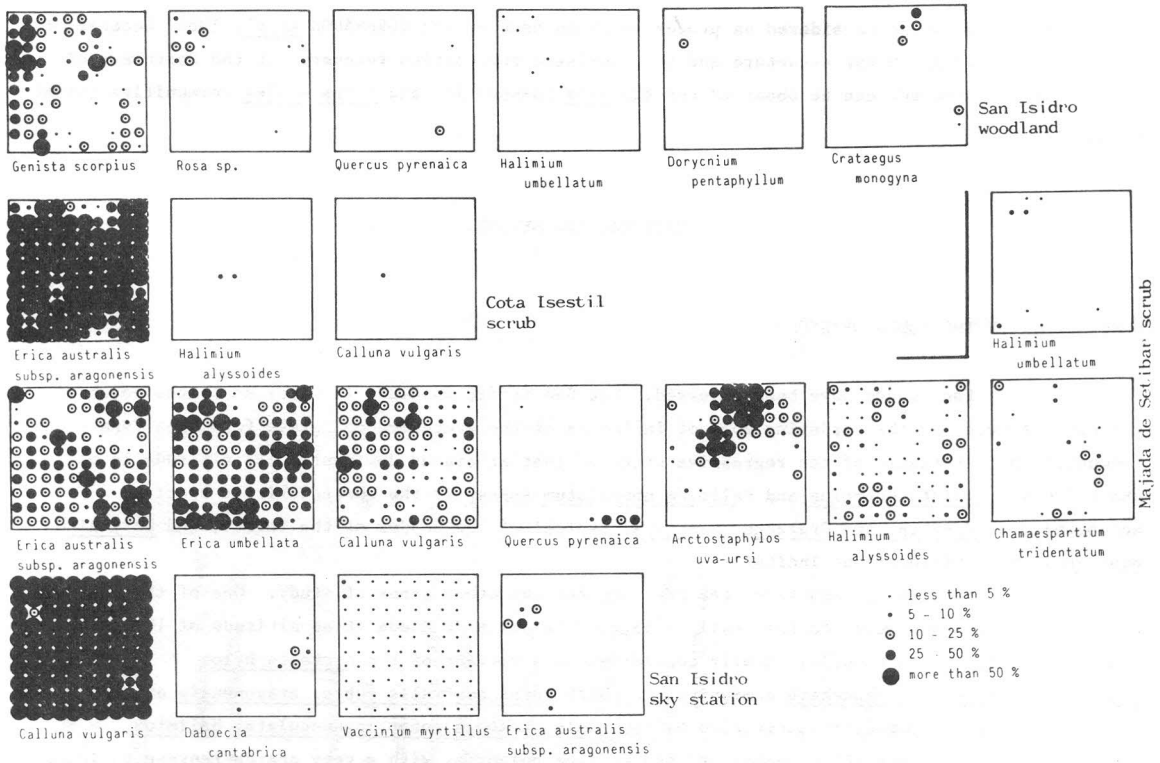


Fig. 1.- Spatial distribution and semiquantitative values of cover of the shrub species found before burning in the four controlled sampling plots.

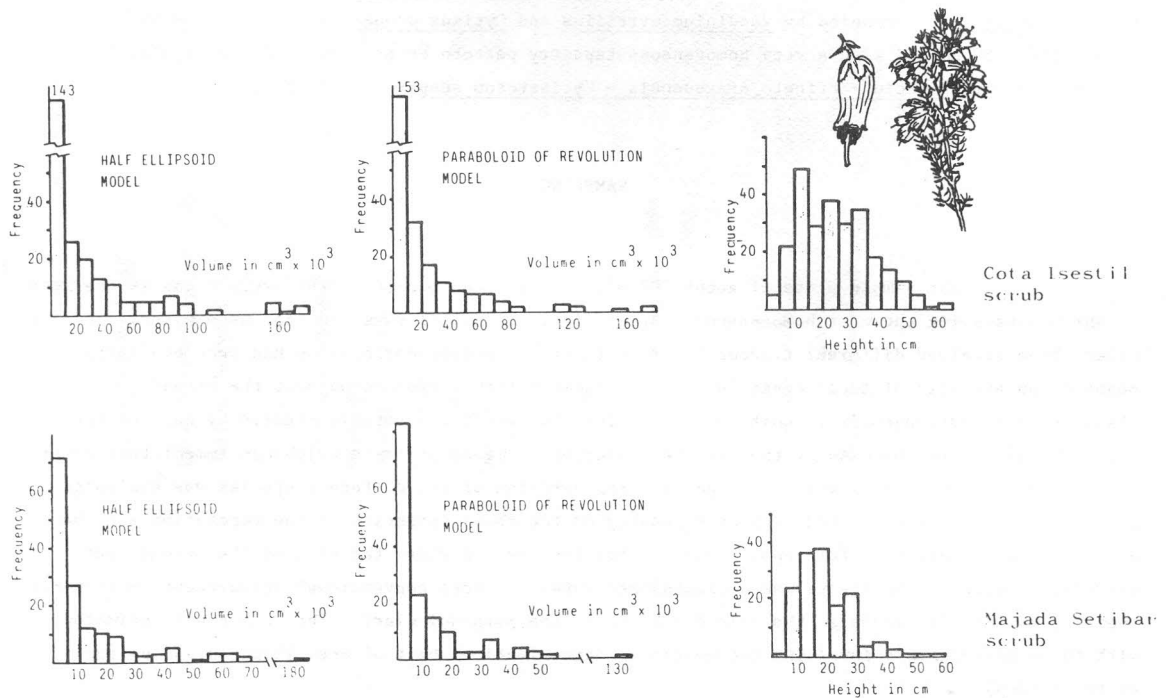


Fig. 2.- Estimated volume by different models and distribution of heights of *Erica australis* subsp. *aragonensis* in two controlled zones.

RESULTS AND DISCUSSION

ORIGINAL SITUATION

The plots burned in each of the study zones offered a semi-quantitative disposition given in Figure 1. The average cover in units in which the species are present, and the total cover of species of shrub found are shown in Table I. In the San Isidro woodland there is a clear domination of Genista scorpius, both in frequency and in abundance. The rest of the accompanying species are represented on only a small scale so that only Rosa sp. exceeds 1% of the total cover. In the Cota Isestil scrub, the species Erica australis appears in all sampling units of 1 m, reaching a cover of 78,6% in the plot, while the two accompanying species are represented by a very low presence and cover. On the contrary, in the Majada of Setibar scrub the values of importance are more divided. Erica australis, Arctostaphylos uva-ursi reaching the highest cover, with outstanding values also for Erica umbellata and Calluna vulgaris. In the San Isidro sky station Calluna vulgaris is evenly distributed while at the same time its cover is high. On the other hand, Vaccinium myrtillus, also distributed in almost all the plots, only represents 2.4% of the total cover.

Table II - Biomass values of the shrub species

	Weight in Kg/100 m ²
<u>San Isidro woodland</u>	
Cutting JUL. 1985	
Genista scorpius	37.7
Rosa sp.	1.0
Dorycnium pentaphyllum	0.3
<u>Cota Isestil scrub</u>	
Cutting JUL. 1985	
Erica australis subsp. aragonensis	165.1
<u>Majada of Setibar scrub</u>	
Cutting JUL. 1985	
Erica australis subsp. aragonensis	31.4
Erica umbellata	13.8
Calluna vulgaris	11.9
Arctostaphylos uva-ursi	6.8
Halimium alyssoides	1.3
Chamaespartium tridentatum	1.2
Quercus pyrenaica	0.5
Halimium umbellatum	Inap.
<u>San Isidro sky station</u>	
Cutting JUL. 1985	
Calluna vulgaris	117.7
Daboecia cantabrica	21.7
Vaccinium myrtillus	0.1

As far as biomass is concerned, and taking into account the species found in the plots with cleared undergrowth, the weight of the above-ground part was calculated, the values being shown in Table II. On the whole there is a good correlation between the biomass and the cover of both plots, with the only outstanding exception being Arctostaphylos uva-ursi in the Majada of Setibar scrub, due to the special manner of growth and distribution of this species. The importance of Erica australis in the Cota Isestil scrub is outstanding because of its great biomass, whilst at the time it appears in this plot as the only representative species. In the San Isidro sky station, with values also over 100 Kg, Calluna vulgaris shares with Daboecia cantabrica, although the latter to a lesser extent, practically the totality of the biomass. In the San Isidro woodland, Genista scorpius is the only significant representative, whilst in the Majada of Setibar scrub the proportion of weight as well as of cover are more evenly distributed amongst the different species.

RESPONSE OF REGENERATION

After the initial sampling, the measurements in successive years are to check that the regeneration of the shrubs has been carried out. Because the response in each of the zones was very different, the method of evaluation was also different and basically determined by the degree of response.

In the San Isidro woodland the presence of sprouts of any of the species was almost imperceptible. The only species in the plot that up to now show some small sprouts are Dorycnium pentaphyllum, Quercus pyrenaica, Cistus laurifolius and Daphne gnidium. In any case, due to its scarcity it can be considered that the biomass is almost non-existent.

In the Cota Isestil scrub, only small sprouts of Erica australis appear, basically from the base of the trunk of each of the stalks burnt, as re-sprouts of the stock, together with some much smaller sprouts, which might have come from seeds. A first sampling carried out in April 1986, taking into account the 100 units of 1 m² and evaluating their cover gave for Erica australis the following values :

n	\bar{x}	\bar{v}	\bar{X}
77	9.5	5.3	7.3

In relation to the sampling prior to the fire this means a proportion of 0.09 with regard to the total cover. The maximum height reached at that time was 40 cm, highlighting the fact that most of the burnt shrubs were re-sprouting.

A second sampling, performed in October 1986, was carried out measuring each stalk individually. Taking as a starting point the values of the projection over the ground of each stalk, the total cover has been estimated taking as the approximate model of projection the surface of an ellipse. The value thus obtained reaches a surface of 24.11 m², which in relation to the cover prior to the burning means a proportion of surface regeneration in the second year of 0.31. Nevertheless it must be taken into account that in the independent surface measurement per stalk, superposition has not been considered, and therefore the real proportion would be considerably smaller.

In the same way, the volume was estimated according to the models of the ellipsoid and the paraboloid of revolution. The volumes thus obtained have been grouped for both models in size types whose graphic expression is reflected in Figure 2. Taking into account the model of the ellipsoid we obtain by simple addition a total volume of 5.98 m³ for the plot of 100 m², with a minimum volume per unit of 4.3 cm³ and a maximum of 0.17 m³. Using the model of the paraboloid, the volumes obtained are slightly lower with a total volume of 4.55 m³. In any event the median value between these two values could be estimated. In the same way, if the initial volume prior to the fire was estimated by taking into account the cover of the plot and the average height (1.20 m), the volume which would be obtained would reach 94.32 m³, and consequently the proportion of regeneration, considering the mean of both models, is 0.05 in volume. The distribution according to size, also expressed graphically in Figure 2, points out as the most common values those defined in the range 10-15 cm, stalks with a height inferior to 5 cm being scarce. The highest value is 61 cm.

In the Majada of Setibar scrub, as for the Cota Isestil scrub, two samplings were also carried out after the burning. In the first one performed in April 1986, the results of which are given in Table III, only two species show a significant cover. One is Arctostaphylos uva-ursi, with elongated and creeping stems and persistent, coriaceous leaves, which because of its aspect and morphological characteristics resists fire well. With a total cover of 11.01; its proportion in relation to the initial situation is 0.25. The other is Erica australis, with a total cover of 3.22%, which therefore as regards the situation prior to burning means a proportion of 0.10. The re-sprouts are still very low, with a maximum height of 20 cm. The presence of other species is not significant.

The second sampling performed in January 1987 was carried out taking into account each stalk independently. The total surface estimated, according to the model of the ellipse, was 11.2%. The proportion as regards the original situation was 0.36 although the same conditions as for the previous plot applied regarding the superposition of the projections. For Arctostaphylos uva-ursi the relation is more real, due to the creeping growth, in such a way that the estimation in this sampling of a total cover of 15.0% means a proportion of regeneration which equals 0.34.

Table III. Average of total cover values of the first sampling made in the Majada of Setibar scrub.

	n	\bar{x}	∇	$\bar{\bar{x}}$
<u>Erica australis</u>	57	5.64	4.49	3.22
<u>Arctostaphylos uva-ursi</u>	54	20.38	15.17	11.01
<u>Erica umbellata</u>	1	15.00	-	0.15
<u>Halimium alyssoides</u>	15	4.26	2.79	0.64
<u>Chamaespartium tridentatum</u>	1	2.00	-	0.02

The volume for Erica australis was also calculated in the same way starting for the two geometrical models above-mentioned (Fig. 2), obtaining for the ellipsoid a total volume of 2.07 m³, with a maximum of 0.18 m³ and a minimum of 12.6 cm³. A total volume of 1.59 m³ results for the paraboloid. The relation between the average value of these estimations and the value of the initial volume, for an average height of 0.80 m, is 0.07, a value which is quite similar to the one obtained for this same species in the previous plot.

The distribution according to height (Fig. 2) defines as the most common values those included in the range 15 to 20 cm, with only one specimen inferior to 5 cm. The maximum height reached was 59 cm.

In the San Isidro sky station, burned in July 1986, in October of that same year there were only three small sprouts of Erica australis with a maximum height of 5 cm.

All the plots will be checked in successive years until they reach a structure similar to the witness plot of the zone. The response of plots of similar characteristics to clearing and uprooting is referred to in other complementary works.

REFERENCES

- BISWELL H.H. (1974). Effects of fire on chaparral. Fire and Ecosystems. T.T. Kozlowski and C.E. Ahlgren. Academic Press. New York. 321-364.
- CASAL M., BASANTA M., GARCIA NOVO F. (1984). La regeneracion de los montes incendiados en Galicia. Univ. de Santiago. Monogr. de la Univ. de Santiago, 99.
- GRANADOS M., MARTIN VINCENTE A., GARCIA NOVO F. (1986). El papel del fuego en los ecosistemas de Donana. Boletín de la estacion central de Ecología, 15 (29), 17-28.
- KEELEY J.E. & KEELEY S.C. (1981). Post-fire regeneration of Southern California chaparral. Am. J. Bot., 68 (4), 524-530.
- NAVEH Z. (1974). Effects of fire in the Mediterranean region. Fire and Ecosystems. T.T. Kozlowski and C.E. Ahlgren. Academic Press. New York, 401-434.
- PAPANASTASIS V.P. (1977). Fire ecology and management of phrygana communities in Greece. Environmental consequences of fire and fuel management in the Mediterranean ecosystems. USDA For. Serv. Gen. Tech. Rep. WO3, 476-482.
- PAPANASTASIS V.P. (1978). Early succession after fire in a maquis-type brushland of N. Greece. Forest, 30, 19-26 .
- PARSONS D.J. (1976). The role of fire in natural communities : An example from the Southern Sierra Nevada, California. Envir. Conserv., 3, 91-99.
- TRABAUD L. (1980). Impact biologique et écologique des feux de végétation sur l'organisation, la structure et l'évolution de la végétation des zones de garrigue du Bas-Languedoc. Thèse de Doctorat d'Etat. Univ. Sci. Tech. Languedoc Montpellier, 288p.
- TRABAUD L. & LEPART J. (1980). Diversity and stability in garrigue ecosystems after fire. Vegetatio, 43 (1-2).