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Vegetative response of *Arctostaphylos uva-ursi* to experimental cutting and burning

J. del Barrio, E. Luis-Calabuig & R. Tárrega
Area de Ecología, Facultad de Biología, Universidad de León, 24071 León, Spain

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Abstract

Arctostaphylos uva-ursi uses vegetative resprouting to recover rapidly after disturbances. This study aims to widen knowledge of its regeneration response, so it was subjected to experimental cutting and burning. Fifteen pairs of small circular plots (50 cm diameter) were situated at random in an area where this species is abundant and forms homogeneous carpets with close to 100% cover. One plot of each pair was burned and the other one was cut. Initial biomass was estimated as dry weight from the cut plots. A 50 cm diameter circular sampling quadrat, divided into two concentric circles, was used in order to determine cover recovery and the way in which this occurred (predominantly by colonization from outside or uniformly over the whole surface). Initial recovery was very fast after both disturbances, exceeding 30% cover from the fourth month. Recovery of aboveground biomass was also similar on comparing both types of disturbance, but statistically significant differences with respect to initial values were detected.

Introduction

Species in the communities that are subjected to frequent disturbances, as occurs with most of Mediterranean ecosystems, can respond by regeneration using vegetative resprout or sexual reproduction from the soil seed bank (Trabaud 1970; Naveh 1974; Keeley 1992b). Vegetative regeneration has advantages in interspecies competition as resprouts will occupy the land rapidly because of their intact radicular system (Keeley & Zeedler 1978; Hanes 1981). However, survival will depend on the type of disturbance, amongst other things. In the case of fire the temperature reached (Canadell *et al.* 1991) and the depth at which buds are situated (Bradstock & Myerscough 1988) are important.

The species of the *Arctostaphylos* genus stand out for their colonizing capacity in ecosystem adapted to fire, such as the California chaparral (Keeley 1992a,b), including species that behave as obligate seeders and others that resprout. Resprouting capacity seems to have, in addition, great importance as a recovery mechanism after other disturbances such as cutting (Tesch & Hobbs 1989).

Arctostaphylos uva-ursi is a dwarf shrub with evergreen coriaceous leaves which grows forming an almost continuous carpet or lawn. Its capacity to survive fires is characteristic, acting as a natural firebreak in many cases as it stops the advance of fire and protects the trees and shrubs around which it grows (Tárrega & Luis 1992). Moreover, it is an efficient soil protector, rapidly colonizing ditches and clearings and halting losses owing to erosion. M'Kada *et al.* (1991) refer to its use in revegetating hillsides and other ground in preference to less resistant ornamental shrubs.

The main aim of this study is the analysis of regeneration response of *Arctostaphylos uva-ursi* after two disturbances, cutting and burning, in terms of cover as well as aboveground biomass. Moreover, we intended to discover whether regeneration on a small scale occurs preferably from the aboveground unaffected stems which gradually invade from close lying areas, or from subterranean organs, and whether this response is different as regards the disturbance.

Considering their importance as a natural firebreak and efficient soil protector, knowledge of the behaviour of *A. uva-ursi* after disturbances is an essential first step in its potential use in prevention and management.

Materials and methods

The study was carried out in the province of León (Central-Northwest Spain) in which *Arctostaphylos uva-ursi* is abundant and forms homogeneous carpets. The study site is included in a patchy area with 'dehesas' of *Quercus pyrenaica*, which are used as pasture for sheep, and heathlands dominated by *Erica australis*, as a consequence of the decrease in livestock usage (caused by the migrations to the cities which started in the 1960s), which has caused the progressive invasion of shrubs in the less used stretches (Ministerio de Agricultura, Pesca y Alimentacón, 1984). Using fires to manage pasture has always been, and still is, normal in this area. The potential community would be a *Quercus pyrenaica* oak grove. The climate is subhumid Mediterranean type with a mean annual rainfall of 927 mm and a mean temperature of 11 °C. The dry period covers only two months in summer and the frost period is from November to April (Ministerio de Agricultura, 1980). The soil is a sandy loam, classified as humic Cambisol (FAO, 1989). It was formed on Tertiary materials siliceous conglomerates (I.G.M.E., 1982). A study area of approximately 4 km^2, basically flat and at a height of 1063 m (MTU coordinates: 30TUN2828), was covered.

In March 1994, fifteen pairs of small (50 cm diameter) circular plots were situated at random where *Arctostaphylos uva-ursi* formed nearly pure stands of approximately 100% cover. Herbaceous species in these plots represented a total cover of less than 1%. One plot of each pair was burned with a blowtorch until the aboveground biomass was completely destroyed, while the other was cut at ground level with pruning shears. Successive samplings (1, 3, 4, 6, 9, 13 and 30 months after treatment) were done to document the recovery of cover (visually estimated) and the method of recolonization. A circular sampling unit with a 50 cm diameter was used. It was divided into two concentric circles (the inner circle with 15 cm radius and the external ring 10 cm wide) designed to show whether regeneration occurred preferably by colonization from outside, from the unaltered stems surrounding the area (in this case cover would be higher in the external ring in the first phases) or uniformly over all the surface, which would indicate the predominance of resprouting from subterranean organs (similar cover in the inner circle and in the external ring).

Pretreatment aboveground biomass was estimated from the cut plots in March 1994, for use as a before-after control. In October 1996, when recovery of cover was physiognomically similar to that of unaltered areas, the 30 treated plots (15 cut and 15 burned) were cut to study their biomass recovery. The biomass in 15 control plots (contemporaneous control), close to each pair of treated plots (the three being within a 25 m^2 surface area), was also cut on the same date to determine whether changes in terms of initial values (from the cut plots in March, 1994), and thus unconnected with the treatments, had occurred. Biomass is expressed as dry weight with the moisture content of each sample also estimated for comparison with weight before drying. A hot air chamber was used for 12 hours at a temperature of 105 °C. In all cases, biomass was estimated for the 50 cm diameter plots, because in this case it was only intended to determine whether biomass recovery was complete after the two disturbances; the differences in the recolonization mechanism would only be appreciable in the initial stages, if they existed.

Cover attained in both the inner circle and the external ring in each sampling period in terms of the treatment applied was compared using two-factor analysis of variance (Factor 1: inner or external position in the quadrat. Factor 2: cutting and burning for 1, 3, 4, 6, 9 and 13 months samplings; and cutting, burning and control in the 30 months sampling). Cover percentages were arcsine transformed before ANOVA. To compare recovery of the aboveground biomass an analysis of variance was also used. In this case it was one way or repeated measures in the case of cut plots (before cutting and 30 months later). The Tukey test (Tukey 1949) was applied for a comparison between pairs when ANOVA was significant. Sample normality had been checked beforehand using the David *et al.* (1954) test and homogeneity of variances with the Cochran (1941) test.

Results

Initial recovery was very fast after both disturbances, exceeding 30% cover from the fourth month, reaching 80% after 30 months. However, control plots had a

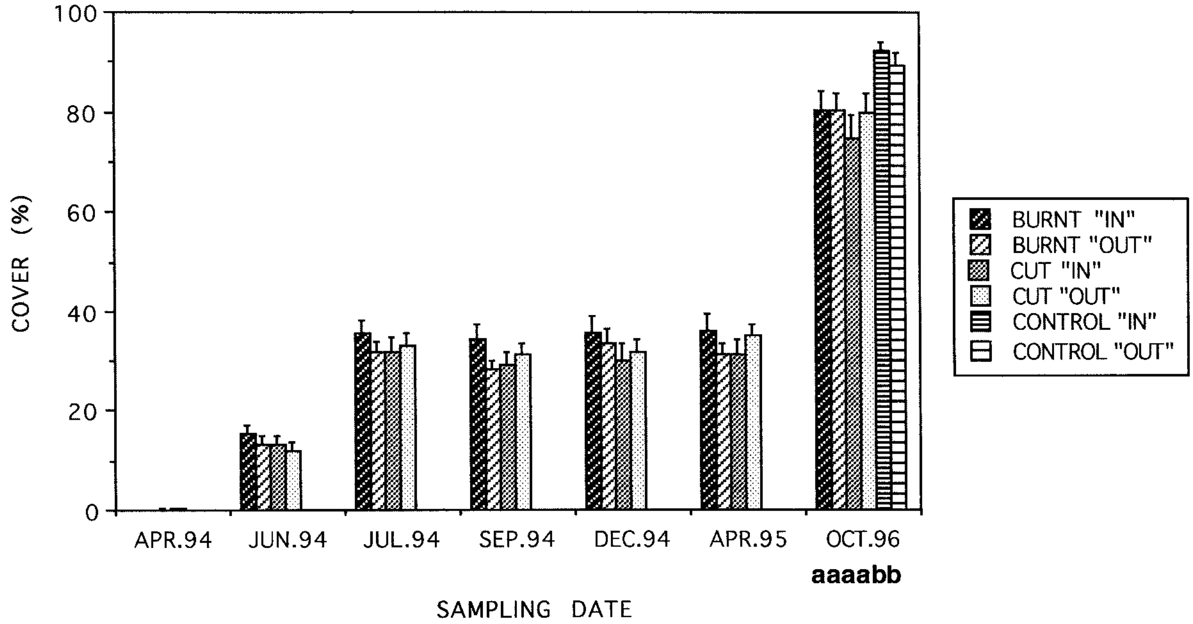

Figure 1. Mean and standard error of *Arctostaphylos uva-ursi* cover values during the study period as regards treatment and position in the sampling unit (In=inner circle; Out=external ring). Different letters in the last sampling period (October 1996) indicate statistically significant differences ($p < 0.05$) in the mean values.

Table 1. ANOVA table for two-factor analysis of variance of cover values (arcsine transformed) in the last sampling (30 months after treatments). Factor 1 (A) Position (external ring and inner circle), factor 2 (B) Treatment (cut, burnt and control).

Source	df	Sum of squares	F-test	*p* value
Position (A)	1	0.0001	0.002	0.964
Treatment (B)	2	1.0310	7.558	0.001
AB	2	0.0590	0.433	0.650
Error	84	5.7270		

Table 2. ANOVA table for biomass values (dry weight) comparing the pretreatment control samples (original stage), the plots 30 months after burning and cutting, and contemporaneous control samples.

Source	df	Sum of squares	F-test
Between groups	3	50901.02	6.5140
Within groups	56	145869.54	$p = 0.0007$
Total	59	196770.56	

mean cover of 90%, the difference being statistically significant ($p < 0.05$) (Figure 1, Table 1). All recovery was from vegetative resprouting. No seedlings of *A. uva-ursi* or any other species were observed. Comparing regeneration response, there is a slightly greater cover in the inner circle of the burned plots whilst the opposite occurs with the cut ones, but the analysis of variance did not detect significant differences in any sampling period. This tendency is no longer observable in the last sampling.

As far as aboveground biomass is concerned, recovery is similar after cutting and burning with mean values close to 700 g m^{-2} 30 months after both types of disturbance. Nevertheless, these values are still significantly lower than those for the control plots in the case of both unaltered ones cut on the same date and those cut at the beginning of the experiment with mean values close to 1 kg m^{-2} (Figure 2, Table 2). Moisture content is high in all the samples, being about 50%. No differences are observed between the plots subjected to the two types of disturbance (48%) or the control plots with different dates (52%). However, differences between the disturbed plots and the controls are appreciable with slightly higher moisture values in the latter, although significance can only be detected at 90%.

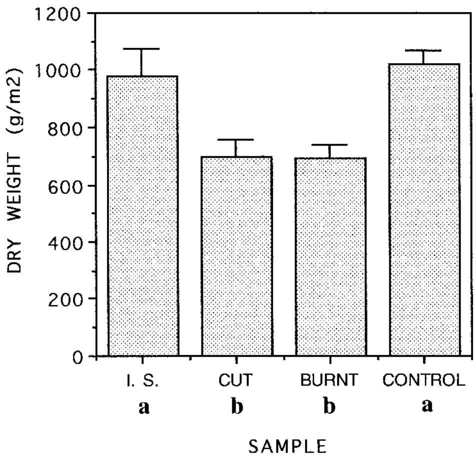

Figure 2. Mean and standard error of *Arctostaphylos uva-ursi* biomass values in the pretreatment control samples (I.S. = initial stage), in the plots 30 months after burning and cutting, and in contemporaneous control samples. Different letters indicate statistically significant differences ($p < 0.05$) in the mean values.

Discussion

Recovery of *Arctostaphylos uva-ursi* cover is very fast, more so than that of most shrub species characteristic of these ecosystems. In nearly monospecific stands of either *Cistus laurifolius* or *C. ladanifer* (obligate seeders), percent cover was less than 20% one year after burning or cutting and had not attained 40% after 3 years (Luis *et al.* 1996). *Erica australis* (resprouter) recovers more slowly than *A. uva-ursi* in similar conditions, so it attained less than 30% cover three years after cutting and burning (Calvo *et al.* 1992) and 10% one year after burning (Luis *et al.* 1987).

The rapid recovery of *A. uva-ursi* after both types of disturbance was exclusively owing to vegetative resprouting, no seedlings were observed. James (1984) considers vegetative regeneration capacity of many Californian chaparral shrubland species to be an adaptive strategy in the face of fire, although Keeley (1992b) points out that they are also capable of resprouting in the absence of fire, which coincides with the results obtained in this study.

After disturbance, woody recovery takes place after an initial proliferation of herbaceous species (Trabaud & Lepart 1980; Casal 1987; Calvo *et al.* 1992; Trabaud 1992; Sabaté & Gracia 1993; Tárrega *et al.* 1995, 1997). The monospecific development of *A. uva-ursi* in the study plots was likely owing to the dense interweaving of roots and rapid vegetative spreading which could inhibit the germination and growth of other species. Keeley (1992a) found that sites dominated by non-seedling producing taxa, like *Arctostaphylos* in California Chaparral, were not invaded by seedlings of other species. The production of long lasting phytotoxins, inhibiting proliferation for up to two years after the shrubland has been eliminated, has also been stated as causing the absence of herbaceous species in other *Arctostaphylos* species understorey (Hanes 1981). However, this is not likely to be the cause in the area studied as *A. uva-ursi* is found in stretches close to the plot sites with other species including herbaceous and woody ones.

Biomass regeneration after disturbances was very quick (70% of pretreatment values after 30 months). Even though *A. uva-ursi* is a creeping bush (maximum height < 15 cm), 1 kg m^{-2} value attained in the control areas is somewhat comparable to the total aboveground biomass values recorded in stands of *Erica australis* in the same area (mean height 1 m), with 1.8 kg m^{-2}; aboveground biomass recovery of *E. australis* was also slower, only 40% of prefire biomass three years after burning (Fernandez *et al.* 1995). Luk'Yanova *et al.* (1990) recorded values of 550 g m^{-2} of *A. uva-ursi* aboveground biomass in the mountain tundra.

Moisture content results coincide with those for similar ecosystems and are generally higher than those for other woody species (*Erica* spp., *Chamaespartium tridentatum...*) present in the same ecosystems (Luis *et al.* 1989). This is probably one of the aspects that condition the resistance of this species to burning in fires that are not too intense. The differences between plots subjected to disturbances and the controls are, in any case, very small and it is unlikely that they could have any repercussions in terms of surviving another fire. The good recovery results for *A. uva-ursi* cover and biomass make it very advisable as a species to encourage in areas of frequent disturbances. Its non-dependence on colonization from outside has to be stressed as it is of great importance in the natural invasion of taluses, but it would make colonization in large burned sections difficult and slow it down if it were the dominant mechanism. The huge regeneration response by resprout after cutting or a moderately intense fire, which manages to destroy the aboveground biomass but does not damage that underground is important in the rapid recovery of disturbed areas, minimizing the risks of erosive effects.

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