Fast regeneration of the tussock grass *Ampelodesmos mauritanica* after clearing

Régénération rapide de la graminée Ampelodesmos mauritanica *après débroussaillement*

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Résumé

Les perturbations par débroussaillement sont une pratique commune dans les formations arbustives méditerranéennes du nord-est de l'Espagne comme technique de prévention contre les incendies afin de réduire la quantité de combustible disponible. Dans cette étude, nous avons comparé la régénération de communautés végétales dominées par des graminées dans des placettes débroussaillées voisines de placettes non débroussaillées. Nous nous sommes particulièrement intéressés à la réponse de la graminée pérenne couvrante Ampelodesmos mauritanica *dans des placettes débroussaillées depuis 6 mois (récemment débroussaillée), depuis 2 ans (débroussaillée une fois) et dans une placette âgée d'une année mais débroussaillée pendant deux années consécutives (débroussaillée deux fois). Les placettes débroussaillées ont retrouvé rapidement leur couverture végétale après le débroussaillement en liaison avec la dominance dans la communauté d'espèces qui rejettent à partir d'organes souterrains suite à la perturbation. La richesse spécifique n'est pas significativement différente entre les placettes débroussaillées et les placettes non débroussaillées adjacentes. De même, le recouvrement végétal total est plus faible dans les placettes récemment débroussaillées par rapport aux placettes adjacentes non débroussaillées, mais il n'y a pas de différence significative entre les placettes débroussaillées une fois et deux fois. Les individus d'* Ampelodesmos mauritanica *tondus ont de nombreux rejets survivants et vigoureux après le débroussaillement. Bien que dans les placettes débroussaillées, les individus d'* Ampelodesmos mauritanica *soient plus petits que dans les placettes adjacentes non débroussaillées, le recouvrement végétal n'y est pas significativement différent. La reprise des plantules est supérieure dans les placettes récemment débroussaillées par rapport aux placettes non débroussaillées adjacentes. Nos résultats suggèrent donc que le débroussaillement n'est pas vraiment un outil de gestion efficace pour réduire l'abondance d'*Ampelodesmos mauritanica. *Il n'est donc pas une technique de prévention efficace contre le feu parce que cette graminée dominante ne montre pas de mortalité après le débroussaillement et accumule du combustible très rapidement après la destruction de sa biomasse épigée.*

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Abstract

Disturbance by clearing is common in Mediterranean shrublands of NE Spain as a fire prevention technique to reduce fuel loads. We compared the regeneration of the vegetation in grass-dominated communities in cleared stands with adjacent non-cleared stands. We especially focussed on the response of the expansive perennial grass Ampelodesmos mauritanica *in a 6 month (recently cleared), two year old (once cleared) stands and in a one-year-old stand cleared in two consecutive years (twice cleared). Cleared plots recovered quickly from clearing due to the dominance in the community of species that resprout from belowground organs after disturbance. The number of species was not significantly different between cleared and adjacent non-cleared plots. Total plant cover was lower in recently cleared plots than in adjacent non-cleared plots, but not significantly different in once and twice cleared plots. Clipped* Ampelodesmos mauritanica *plants had high survival and vigorous resprouting after clearing. Although in cleared plots* Ampelodesmos mauritanica *plants were smaller than in adjacent non-cleared plots, cover was not significantly different. Seedling recruitment was higher in recently cleared plots than in adjacent non-cleared plots. Our results suggest that clearing is not a very effective management tool for reducing* Ampelodesmos mauritanica *abundance and as a fire-prevention technique because this dominant grass shows no mortality after clearing and accumulates fuel loads very fast after aboveground biomass removal.*

Key-words

Disturbance, fire prevention, grass expansion, Mediterranean vegetation, resprouting, seedling establishment.

Mots-clés

Perturbation, prévention contre l'incendie, extension des graminées, végétation méditerranéenne, rejets, installation des plantules.

Introduction

Beside wildfires, Mediterranean Basin plant communities are subjected to other man-induced disturbances such as clearing and selective thinning for increasing tree wood productivity or for fire prevention (Rico *et al.*, 1981). These disturbances are, more frequent and usually restricted to smaller patch sizes than fire, and thus may have different effects on community structure and dynamics (Malanson, 1984). However, despite the great amount of information regarding resprouting and seeding regeneration of Mediterranean species after fire (Trabaud, 1981; 1994), few studies have addressed these regeneration mechanisms after aerial biomass removal by clearing. Some studies have described patterns of regeneration in communities dominated by shrub or woody species (Retana *et al.*, 1991; Giovannini *et al.*, 1992; Perevolotsky & Haimov, 1992; Herrera, 1997; Lloret & Vilà, 1997; Riba, 1997), but there is no information on regeneration after clearing in stands dominated by grass species.

In Spain, prevention of fire risk is one of the main goals to avoid catastrophic wildfires with large ecologic and ecologic costs (ICONA, 1988). Preventive techniques are mostly designed to decrease fuel loads and highly flammable species while enhancing protected species performance. In Catalonia (NE Spain) there is a great investment to prevent fire risk by manual or mechanical clearing of the vegetation in selected areas such as belts beside roads and tracks, below power lines or next to urbanized areas (Rico *et al.*, 1981; Terradas, 1996). Although this technique is fairly expensive (900 € = 1500 US$ per ha approximately) depending on the method used, vegetation density and ground heterogeneity, (TRAGSA, pers. com.) few studies have investigated vegetation responses after clearing in order to quantify the effectiveness of this fire prevention technique to build belts of low fire risk.

Ampelodesmos mauritanica is a perennial tussock grass that has been suggested to be expanding (sensu Pyšek, 1995) in coastal shrubland communities of northeastern Spain (ORCA, 1985) and the Balearic Islands (Castelló & Mayol, 1987). In Mallorca it forms extensive and thick tall prairies known as "carritxeres" which are believed to be favoured by repeated fire (Castelló & Mayol, 1987). Managers are interested in reducing dominance of *A. mauritanica* for two reasons: 1) because of its high flammability due to its high accumulation of fuel loads and standing dead material (Vilà *et al.*, 2001), and 2) because stands dominated by this grass have low plant species diversity perhaps due to the inhibitory effects of the grass on the recruitment of other species (Castelló & Mayol, 1987). In this study we investigate the effect of mechanical clearing on vegetation regeneration of communities dominated by *A. mauritanica* by comparing cleared stands with adjacent non-cleared stands in a protected area south of Barcelona (Spain). The main objective was to determine if clearing is effective in controlling *A. mauritanica* abundance and reducing fire risk.

Methods

Study species and study sites

Ampelodesmos mauritanica (Poiret) T. Durand et Schinz (Poaceae) is a large, C_3, tussock grass patchily distributed in coastal, usually karstic areas of the western Mediterranean Basin, eastwards to western Greece. Plants may attain 100 cm in diameter and produce up to 25 large inflorescences at the top of 2-3.5 m high reproductive stalks during the spring (Bolòs *et al.*, 1990). Seeds are wind dispersed in late summer and fall. *Ampelodesmos mauritanica* (*Ampelodesmos* hereafter) vigorously regrows after aerial biomass removal from rhizomes situated at the crown. *Ampelodesmos* could have been introduced in Catalonia and could have been introduced from the Balearic Islands in the XVIII century as horse fodder (Montserrat, 1989). *Ampelodesmos* may be expanding in Catalonia (ORCA, 1985) and Mallorca due to its fast regeneration after fire (Castelló & Mayol, 1987; Salvador, 1987; Vilà et *al.*, 2000).

The study site was at the Garraf Natural Park (Garraf hereafter) located about 30 Km south of Barcelona. The area (almost 10000 ha) is a karstic massif ranging from sea level to 600 m altitude. The climate is typically Mediterranean. At the nearest weather station (Viladecans), mean annual rainfall is 550 mm, with a pronounced summer drought. Mean annual temperature is 17 °C. Mean maximum and minimum temperatures are reached in July (28 °C) and January (0.5 °C), respectively. Wildfires deliberately and undeliverately produced by man are frequent in Garraf (Papió 1994). The survey was conducted in a 4800 ha area that had been burned in July 1982 and again in April 1994.

In this area a vegetation management program conducted by park managers was started two years after the 1994 fire with the goal of reducing fuel loads in belts along track and roadsides. Mechanical selective clearing of the aboveground biomass except for protected (e.g. *Chamaerops* *humilis*), slow growing (e.g. *Juniperus oxycedrus*) and low flammable (e.g. *Arbutus unedo*) species was conducted in three sites at different times. In fall 1996 a 4.8 km long belt ("once cleared") and an 8.3 km long belt were cleared. In fall 1997 the 8.3 km long belt was cleared again ("twice cleared"). In spring 1998 a new 2.8 km long belt was cleared at another site ("recently cleared"). On average, the belts were 20 m wide. Minimum and maximum distance between cleared belts were 1 and 4 km. There are no records of stands cleared in Garraf before 1996.

Field survey

From September to November 1998 a survey was conducted to compare vegetation structure in the 3 cleared and adjacent control stands. We mainly focussed on *Ampelodesmos* regeneration. Twenty randomised paired plots that were at least 100 m apart were selected along each cleared belt. Each paired plot consisted of a 10 x 5 m plot in the cleared belt and a 10 x 5 m plot in the adjacent non-cleared area (control plot). Cleared plots were placed 5 m from the adjacent cleared stand to avoid edge effects. This distance would be enough taking into account the size and density of the species. Aerial photographs from 1994 show that canopy structure was similar in the cleared belts as compared to the adjacent non-cleared areas before the treatments.

Vegetation cover of perennial species in each plot was estimated by the point intercept sampling procedure by detecting the presence of species every 0.5 m along the four sides of the plot quadrat. Thus, in each stand a total of 60 points were used to estimate plant cover. The number of perennial species within the plot was also counted.

All regrowing and non-regrowing *Ampelodesmos* plants per plot were counted and the number of plants with reproductive stalks was noted. The percentage of *Ampelodesmos* mortality after clearing was estimated by counting clipped rhizomes that had not regrown. The size of *Ampelodesmos* plants was estimated as the cylinder volume calculated from the height of the plant vegetative part and the crown area calculated from the mean value of the longest canopy diameter and the perpendicular to it. Previous allometric analysis (Vilà *et al.*, 2001) demonstrated that the cylinder volume (V) of the plant was a good prediction of plant aerial biomass (W) ($\ln W = -5.67 + 828 \ln V$, $r^2 = 0.914$, $n = 51$). Because of the small size of seedlings (less than 2 cm in height) and because they tend to be more numerous than mature plants, seedling abundance was recorded in three 40 x 40 cm subplots randomly selected within each plot.

Statistical analysis

We compared differences between cleared and control plots within a site in species richness (number of species per plot), species cover, average *Ampelodesmos* volume and height, percentage of reproductive *Ampelodesmos* plants and *Ampelodesmos* seedling density (averaged among the three subplots within each plot) by paired t-tests. Data were log (x + 1) transformed before analysis to normalize data. We could not compare differences among clearing treatments because they were not randomly assigned among areas.

RESULTS

Species richness per plot ranged from 4 to 12 species (average 6 or 7 species per plot). There was no significant effect of clearing on species richness (once cleared: t-value = -0.55, p = 0.59; twice cleared: t-value = 1.21, p = 0.24; recently cleared: t- value = 0.65, p = 0.53).

Total plant cover was not significantly different between cleared and control plots except in recently cleared plots where cleared plots had significantly lower cover than controls (table 1). In recently cleared plots, only *Rosmarinus officinalis*, *Ulex parviflorus* and *Globularia alypum* had significantly lower cover than in adjacent control plots. In twice cleared plots, only *Erica multiflora* cover was lower than in adjacent control plots (table 1).

All clipped *Ampelodesmos* plant survived. All of the 769 *Ampelodesmos* plants measured that had been cleared resprouted quickly. *Ampelodesmos* were significantly larger (fig. 1A) and taller (fig. 1B) in control plots than in cleared plots. However, *Ampelodesmos* cover was not significantly different between control and cleared plots (table 1). All cleared plots had lower percentage of reproductive *Ampelodesmos* plants than in adjacent control plots (fig. 1C). However, density of seedlings was higher in recently cleared plots than in adjacent control plots (fig. 1D).

DISCUSSION

All the studied species that resprout after fire in Mediterranean garrigues (Trabaud & Lepart, 1980) were also found to resprout after clearing. Six months after clearing the vegetation in our study site already covered 65 %

Species	Once cleared	Control	t-value (p)
Ampelodesmos mauritanica (R)	41.17 ± 4.57	35.86 ± 3.87	1.45 (0.16)
Quercus coccifera (R)	38.75 ± 3.55	36.58 ± 3.58	0.73 (0.47)
Pistacia lentiscus (R)	4.10 ± 0.77	3.75 ± 0.70	0.40 (0.69)
Coronilla minima	6.00 ± 2.07	5.42 ± 1.58	1.42 (0.59)
Brachypodium retusum (R)	15.58 ± 2.60	14.00 ± 2.65	0.56 (0.58)
Erica multiflora (R)	1.25 ± 0.34	5.47 ± 1.77	2.10 (0.08)
Phillyrea latifolia (R)	1.58 ± 1.06	0.17 ± 0.17	1.31 (0.21)
Cistus albidus	1.33 ± 0.71	0.17 ± 0.17	1.56 (0.13)
Cistus salviifolius	0.67 ± 0.28	1.08 ± 0.49	1.04 (0.31)
Globularia alypum (R)	3.66 ± 2.55	0.50 ± 0.34	1.24 (0.23)
Total	98.83 ± 5.15	92.25 ± 2.77	1.26 (0.22)
Species	**Twice cleared**	**Control**	**t-value (p)**
Ampelodesmos mauritanica (R)	16.50 ± 2.52	22.08 ± 2.85	1.66 (0.11)
Quercus coccifera (R)	20.17 ± 5.14	20.50 ± 4.45	0.09 (0.92)
Pistacia lentiscus (R)	6.50 ± 1.24	7.50 ± 1.30	0.61 (0.55)
Coronilla minima	1.43 ± 0.59	0.57 ± 0.41	1.16 (0.26)
Brachypodium retusum (R)	25.67 ± 4.97	26.25 ± 5.22	0.14 (0.89)
Erica multiflora (R)	0.42 ± 0.34	1.00 ± 0.39	2.33 (0.03)
Phillyrea latifolia (R)	1.17 ± 0.63	11.00 ± 0.42	0.33 (0.75)
Cistus albidus	1.00 ± 0.49	1.92 ± 0.91	0.38 (0.71)
Cistus salviifolius	1.92 ± 1.12	0.80± 0.68	1.05 (0.31)
Globularia alypum (R)	3.83 ± 0.41	3.83 ± 2.20	0.18 (0.86)
Total	86.08 ± 6.81	93.08 ± 6.05	0.79 (0.44)
Species	**Recently cleared**	**Control**	**t-value (p)**
Ampelodesmos mauritanica (R)	7.84 ± 1.83	11.74 ± 3.24	0.32 (0.75)
Quercus coccifera (R)	12.17 ± 2.73	17.75 ± 4.8	1.30 (0.18)
Pistacia lentiscus (R)	4.42 ± 1.34	4.58 ± 1	0.14 (0.89)
Coronilla minima	6.58 ± 1.05	4.67 ± 0.97	1.39 (0.18)
Brachypodium retusum (R)	21.5 ± 3.25	16.58 ± 2.21	1.47 (0.16)
Erica multiflora (R)	2.25 ± 0.73	3.75 ± 1.19	1.48 (0.13)
Phillyrea latifolia (R)	1.25 ± 0.58	2.50 ± 1.15	1.56 (0.13)
Rosmarinus officinalis	0	6.33 ± 1.73	3.07 (0.006)
Ulex parviflorus	0	4.02 ± 0.9	2.13 (0.05)
Globularia alypum (R)	2.08 ± 0.63	4.75 ± 1.19	2.75 (0.02)
Total	65.33 ± 2.59	86.83 ± 5.03	3.95 (0.0009)

Table 1. Plant cover of the 10 most dominant species in cleared and adjacent non-cleared plots. (R = species that resprout from belowground structures).

of the soil surface with *Ampelodesmos*, *Quercus coccifera* and *Brachypodium retusum* as the dominant species, just as in control plots. *Quercus coccifera* sprouted vigorously from stolons after clearing as it does after fire (Malanson & Trabaud, 1988). However, most species (e.g. *Pistacia lentiscus*, *Erica multiflora*, *Globularia alypum*) resprouted from a well-formed burl or the root system that stores nutrient resources and a bud bank (James, 1984). Differences in plant cover between recently cleared plots and control plots were due to mortality of non-resprouting species (e.g. *Rosmarinus officinalis*, *Ulex parviflorus*) that relay on their seed bank for regeneration after disturbance.

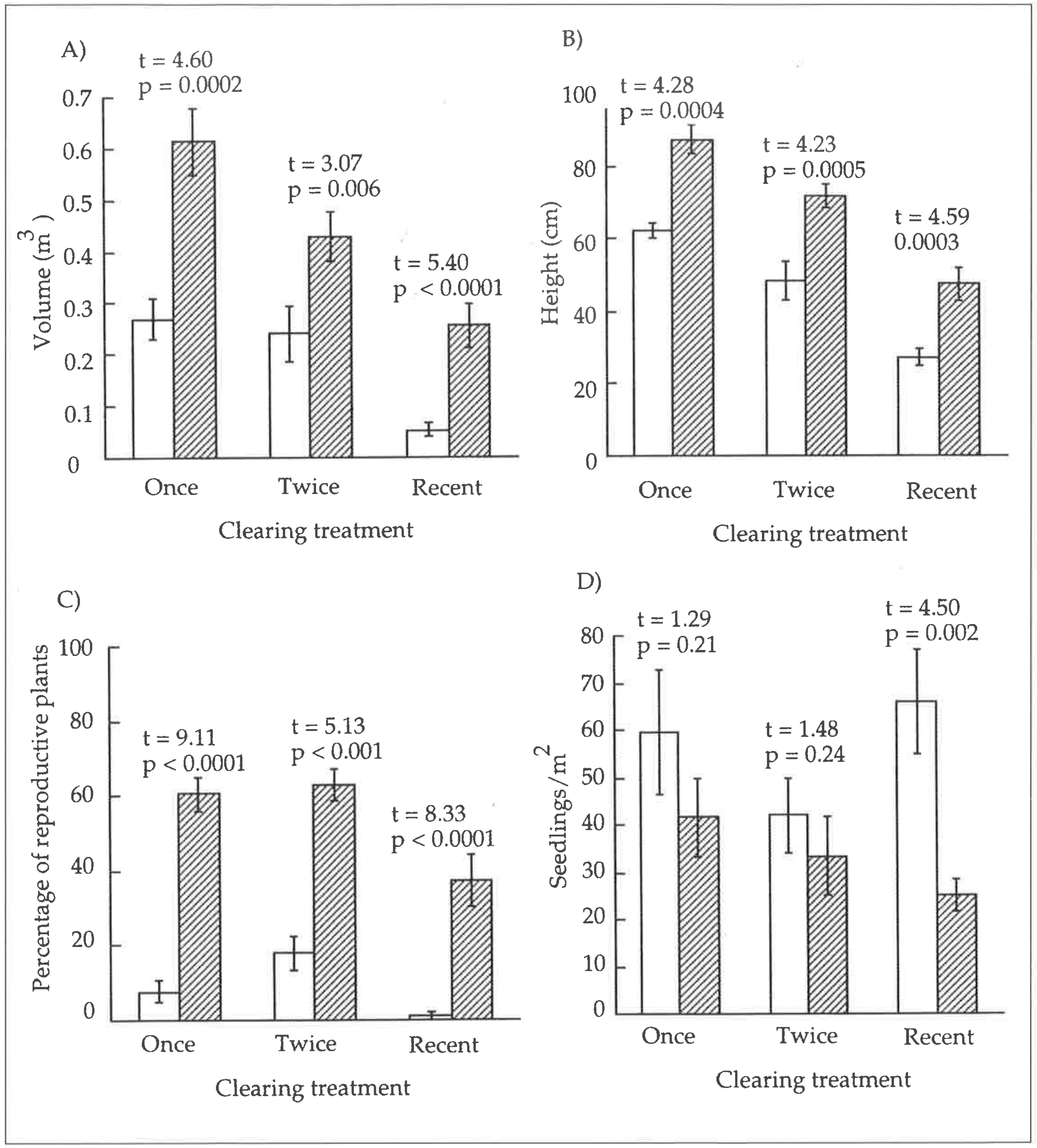

Figure 1. Ampelodesmos mauritanica *volume (A), height per plant (B), percentage of reproductive plants (C) and seedling density (D) in cleared (open bars) and in adjacent control (shaded bars) plots in Garraf. Results of paired t-test comparisons are indicated (n = 20).*

As for resprouting species, the grass *Ampelodesmos* displayed a spectacular response to clearing. New tillers were quickly formed from tussocks contributing to plant survival. *Ampelodesmos* resprouting is also very vigorous after fire (Vilà *et al.*, 2001). Fast regrowth of perennial grasses regardless of the cause of disturbance has been described in species subjected to fire, clearing and herbivory (Westoby, 1980; Caldwell *et al.*, 1981; Van der Toorn & Mook, 1982). Regrowth of tillers is stimulated by intrinsic factors (hormonal stimulation after release from apical dominance inhibition) and also by the temporary decrease of competition by neighbors after clearing. The positive response of *Ampelodesmos* to clearing matches other studies conducted in temperate grasslands (Malanson, 1984; Mueggler, 1972). For example, *Agropyron spicatum* recovered from the adverse effects of clipping if neighbors were also clipped (Mueggler, 1972). Similarly, defoliated *Andropogon gerardii* plants had higher leaf biomass under reduced competition than plants in full competition conditions (Archer & Detling, 1984).

Ampelodesmos plants produced seeds fast, too. Plants produced reproductive stalks one year after aboveground biomass removal and seedling recruitment was stimulated shortly after clearing. *Ampelodesmos* seedling recruitment was higher in recently cleared plots than in adjacent control plots. Since very few 6 month-old *Ampelodesmos* plants produced reproductive stalks but seedling recruitment was very high, two causes could explain this pattern. After clearing seeds from the seed bank could be stimulated or seedling mortality could be reduced due to vegetation and litter removal. Open areas could have more seedlings because plant competition is reduced when vegetation is removed or absent (Herrera, 1997; Vilà & Lloret, 2000). Several studies have also demonstrated that litter reduces seed germination and seedling establishment (Xiong & Nilsson, 1999). The removal of *Ampelodesmos* implies the removal of a large amount of standing dead material that can interfere with seedling recruitment. Both hypothesis seams plausible.

In the last three decades the study of regeneration of Mediterranean sclerophyllous shrublands has concentrated on the regeneration of woody species after fire (Naveh, 1974; Trabaud, 1981; 1994). However, clearing is also a very common disturbance especially in NE Spain and SE France that deserves further research. Land abandonment in this region has caused an increase in vegetation cover that increases fire risk (Debussche *et al.*, 1999). From the management point of view, clearing is not a very effective management tool for fire-prevention in the studied vegetation type because *Ampelodesmos* is very dominant, and shows no mortality after clearing; this grass is one of most flammable species in the community (Vilà *et al.*, 2001) and accumulates fuel loads very fast after aboveground biomass removal.

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References

Archer S. & Detling, J.K., 1984. The effects of defoliation and competition on regrowth of tillers of two North American mixed-grass prairie graminoids. *Oikos*, 43: 351-357

Bolòs O., Vigo J., Masalles R.M. & Ninot J.M., 1990. *Flora Manual dels Països Catalans*, Ed. Pòrtic, Barcelona.

Caldwell M.M., Richards J.H., Johnson D.A., Nowak R.S. & Dzurec R.S., 1981. Coping with herbivory: photosynthetic capacity and resource allocation in two semiarid *Agropiron* bunchgrasses. *Oecologia*, 50: 14-24.

Castelló M. & Mayol J., 1987. La explotación arcaica del carritx *Ampelodesmos mauritanicum* Poiret. Durd et. Schinz en Mallorca. Ponencias y Comunicaciones de la XXVII Reunión Científica de la Sociedad Española para el Estudio de los Pastos, Mahó, Palma.

Debussche M., Lepart J. & Dervieux A., 1999. Mediterranean landscape changes: evidence from old postcards. *Global Ecol. Biogeogr. Letters*, 8: 3-16.

Giovannini, G., Perulli D., Puissi P. & Salbitano F., 1992. Ecology of vegetative regeneration after coppicing in macchia stands in central Italy. *Vegetatio*, 99-100: 331-343.

Herrera J., 1997. Effects of disturbance on the reproductive potential of *Lavandula stoechas*, a Mediterranean sclerophyllous shrub. *Ecography*, 20: 88-95.

ICONA, 1988. Documentos del Seminario sobre métodos y equipos para la prevención de incendios forestales, ICONA, Madrid.

James S., 1984. Lignotubers and burls-their structure, function and ecological significance in Mediterranean ecosystems. *Bot. Review*, 50: 225-260.

LLORET F. & VILÀ M., 1997. Clearing of vegetation in Mediterranean garrigue: response after a wildfire. *Forest Ecol. Manag.,* 93: 227-234.

MALANSON G.P., 1984. Intensity as a third factor of disturbance regime and its effect on species diversity. *Oikos,* 43: 411-413.

MALANSON G.P. & TRABAUD L., 1988. Vigour of post-fire resprouting by *Quercus coccifera* L. *J. Ecol.,* 76: 351-365.

MONTSERRAT P., 1989. *Flora de la Cordillera Litoral Catalana,* Caixa d'Estalvis Laietana, Barcelona.

MUEGGLER W.F., 1972. Influence of competition on the response of bluebunch wheatgrass to clipping. *J. Range Manag.,* 25: 88-92.

NAVEH Z., 1974. Effects of fire in the Mediterranean Region. *In:* Kozlowski T. T. & Ahlgren C. E. (eds.). *Fire and ecosystems.* Academic Press, New York: 401-434.

ORCA, 1985. *Atlas Corològic de la Flora Vascular dels Països Catalans, Volum I, Institut d'Estudis Catalâns,* Barcelona.

PAPIÓ C., 1994. *Ecologia del foc i regeneració en garrigues i pinedes mediterrànies.* Institut d'Estudis Catalans, Barcelona.

PEREVOLOTSKY A. & HAIMOV Y., 1992. The effect of thinning and goat browsing on the structure and development of Mediterranean woodland in Israel. *Forest Ecol. Manag.,* 49: 61-74.

PYŠEK P., 1995. On the terminology used in plant invasion studies. *In:* Pyšek P. Prach K., Rejmánek M. & Wade M.(eds.), *Plant invasion. General aspects and special problems.* SPB Academic Publishing, Amsterdam: 71-81.

RETANA J., RIBA M., CASTELL C. & ESPELTA J.M., 1991. Regeneration by sprouting of holm-oak (*Quercus ilex*) stands exploited by selection thinning. *Vegetatio,* 99-100: 355-364.

RIBA M., 1997. Effects of cutting and rainfall pattern on resprouting vigour and growth of *Erica arborea* L. *J. Veget. Sci.,* 8: 401-404.

RICO F., VÉLEZ R., VILLAESCUSA R., RODERO F. & BAZ L., 1981. *Técnicas para la defensa contra incendios forestales,* Monografia 24, ICONA, Ministerio de Agricultura, Madrid.

SALVADOR R., 1987. *Las Baleares por la palabra y el grabado,* Volumen V, Translation of the original publication in Leizpig 1987, Caja de Ahorros de las Baleares, Palma de Mallorca.

TERRADAS J., 1996. Mesures específiques de gestió per a la prevenció d'incendis. *In:* Terradas J. (ed.). *Ecologia del foc,* Proa, Barcelona: 523-537.

TRABAUD L., 1981. Man and fire: impacts on Mediterranean vegetation. *In:* Di Castri F., Goodall D.W. & Specht R.L. (eds.). *Ecosystems of the world* 11. *Mediterranean-type shrublands,* Elsevier, Amsterdam: 523-537.

TRABAUD L., 1994. Postfire Plant Community Dynamics in the Mediterranean Basin. *In:* Moreno J.M. & Oechel W.C. (eds.). *The role of fire in Mediterranean-type ecosystems,* Springer-Verlag, New York: 1-15.

TRABAUD L. & LEPART J., 1980. Diversity and stability in garrigue ecosystems after fire. *Vegetatio,* 43: 49-57.

VAN DER TOORN J. & MOOK J.H., 1982. The influence of environmental factors and management on stands of *Phragmites australis. J. Appl. Ecol.,* 19: 477-499.

VILÀ M. & LLORET F., 2000. Seed dynamics of the mast seeding tussock grass *Ampelodermos* mauritanica in Mediterranean shrublands. *J. Ecol.,* 88: 479-491.

VILÀ M., LLORET F., OGHERI E. & TERRADAS J., 2001. Positive fire-grass feedback in Mediterranean Basin woodlands. *Forest Ecol. Manag.,* 147: 3-14.

WESTOBY M., 1980. Relations between genet and tiller population dynamics: survival of *Phalaris tuberosa* tillers after clipping. *J. Ecol.,* 68: 863-869.

XIONG S. & NILSSON C., 1999. The effects of plant litter on vegetation: a meta-analysis. *J. Ecol.,* 87: 984-994.