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in

Casasús I. (ed.), Lombardi G. (ed.).
Mountain pastures and livestock farming facing uncertainty: environmental, technical and socio-economic challenges

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 116

2016
pages 287-290

The potential role of seedbanks in maintaining grassland vegetation in a Mediterranean oak woodland

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Abstract. Soil seedbank ecology, by allowing substantial flexibility for potential changes in plant communities, can provide important information about vegetation development and persistence. It partly reflects the history of the vegetation and its composition. Most plant species can produce seeds that remain dormant in the soil for several years. During 3-year, our study has investigated on the potential role of the seed bank in maintaining grassland vegetation in silvo-pastoral systems and the effect of grazing regime on seedbank dynamics. We have analysed across 11 different sites, taking soil-core samples of 8 cm in diameter and 10 cm deep, both collected in ungrazed (fenced) and grazed (unfenced) areas. Results highlight, although without interaction, the effects of grazing regime and year, both on seed dispersal bank size and germinable seed fraction of the seed bank, and pointed out the potential role of permanent seed bank on future establishment of grassland.

Keywords. Soil seedbank – Grassland communities – Sylvo-pastoral systems – Grazing.

Le rôle potentiel des banques de semences dans le maintien de la végétation des prairies dans un bois de chênes méditerranéens

Résumé. *L'écologie de la banque de semences du sol, en permettant une grande flexibilité pour les changements potentiels dans les communautés végétales, peut fournir des informations importantes sur le développement de la végétation et de sa persistance. Il reflète en partie l'histoire de la végétation et de son composition. La plupart des espèces de plantes peuvent produire des graines qui restent en dormance dans le sol pendant plusieurs années. Cette étude de 3 ans a analysé le rôle potentiel de la banque de semences dans le maintien de la végétation des prairies dans un système sylvo-pastoral, et l'effet du pâturage sur sa dynamique. Nous avons analysés, dans 11 sites différents, des échantillons du sol de base de 8 cm de diamètre et 10 cm de profondeur, également prélevés en zones pâturées et non pâturées, afin d'évaluer les effets de pâturage. Les résultats soulignent, bien que sans interaction, les effets du régime de pâturage et de l'année, à la fois sur la taille et sur la fraction de semences germinables et le rôle potentiel de la fraction permanente de la banque de semences sur le pâturage.*

Mots-clés. *Banque de semences du sol – Communautés prairiales – Système sylvo-pastoraux – Pâturage.*

I – Introduction

Inland abandonment is a crucial phenomenon that is occurring in several Mediterranean countries. Consequently, the disappearing of traditional activities in rural areas, such as silvopastoralism, means not only a lack of typical micro economies, but also the risk of strongly affecting the structure of plant communities, with relevant effects on biodiversity, wildfire prevention and erosion control at the landscape level (Hobbs *et al*., 2007). The species composition of a plant community may be assessed through the vegetative spread of plant species and the determining of seedlings establishment from the seed bank (Peco *et al.,* 1998). Seed banks have received considerable at-

tention in relation to the conservation, management and restoration of natural ecosystems because soil seed banks are important components of vegetation dynamics and resilience (Bertiller and Aloia, 1997). Soil seed bank composition is influenced by the surrounding vegetation and former successional stages, reflecting partly the history of the vegetation, and its composition (Godefroid *et al.,* 2006) and can undergo significant changes depending on the management applied (Wellstein *et al.,* 2007). Ecologists and conservationists have looked at the role of seed banks in woodland and forest regeneration presumed that play a role in the rehabilitation of degraded ecosystems (Erenler *et al.,* 2010). Seed bank ecology allows a substantial flexibility for potential changes in the plant community and can provide important information on the dynamic of vegetation and its persistence. The objectives of our research were to evaluate the role of grazing on the dimension of seed bank components (germinable, RGS and permanent, PSB) and so, to check out the probable effects of abandonment of rural areas on the resilience of silvopasture vegetation.

II – Materials and methods

The trial was carried out during 3 years (2012-2014) in the Forest of Monte Pisanu (40°43' 145 N, 8° 97' 838 E, Central Sardinia, Italy), identified as a Site of Community Importance (SIC). The vegetation is characterised by *Quercus ilex*, *Quercus pubescens*, *Taxus bacata*, *Ilex aquifolium*, *Quercus suber* and *Castanea sativa*. Around 200 herbaceous species were identified, mainly therophytes, hemicryptophytes and geophytes, referable to 34 families, mainly Graminaceae, Leguminosae and Compositae, with a high presence of *Asphodelus microcarpus* Salzm. *et* Viv. (Re *et al*., 2014). In this area, grazing is commonly carried out where the tree canopy is open or less dense (gaps, cleared areas). It is rotational heavy for dairy sheep and continuous light for cattle, with an estimated livestock of 650 Livestock Units (L.U.) per year on a total surface of 2000 ha. Eleven representative grazed areas, located between 600 m and 1200 m a.s.l., were identified. In order to simulate the exclusion of grazers and the consequent response of seedbank accumulation, metallic cages of 4 m^2 were placed on each site. The readily germinable seed bank (RGS) was assessed by collecting five intact soil cores (8 cm large and 10 cm deep) in each site, three in the grazed area and two inside the cage and counting the number of germinated seeds (seedlings) after one month in open-air conditions. Then, the soil samples, were washed on a fine sieve (mesh width 0.2 mm) and placed in Petri dishes to be processed to the following germination/dormancy breakdown treatments (Perez *et al*., 1998): (i) watered field conditions; 21 days diurnal cycle of 8/16 darkness/light at 20/30°C; (ii) 21 days dormancy assessment test, 3 - 5°C; and (iii) 35 days chemical breakdown test, 600 mg/kg-solution of gibberellic acid, diurnal cycle of 8/16 darkness/light at 15/35°C. The number of seedlings counted after these treatments was considered as an estimate of the PSB (Permanent Seed Bank). TSB (Total Seed Bank) was estimated by summing all the seeds germinated in watered field conditions (RGS) and after each dormancy breakdown treatment (PSB). Combined ANOVA over the three years on seedlings number per square meter of each TSB component was performed (GLM Procedure, Statgraphics XVI).

III – Results and discussion

The impact of grazing on seed bank species richness and composition has been studied mainly in grasslands and to a lesser extent in forests, scrubs and rangelands. The RGS size ranged from 28,264 seedlings m^{-2} in MP11 (2012) to 995 seedlings m^{-2} in MP4 (2013) in grazed area and from 20,303 in MP8 (2012) to 299 seedlings m^{-2} in MP4 (2013) in ungrazed areas (Table 1). PSB size ranged between 9,289 (MP2, 2014) and 597 (MP1, 2014) seedlings m^{-2} in grazed areas and from 14,630 (MP2, 2014) and 597 (MP5, 2013) in ungrazed areas. Both in grazed and ungrazed areas, we have found that average grasses abundance (data not shown) was higher than the other species, as well as reported by Koc *et al.* (2013), even if in a study area with different climate conditions.

Table 1. Number of seedlings m^{-2} (RGS and PSB) in grazed and ungrazed conditions

		2012				2013				2014			
		RGS†		PSB†		RGS		PSB		RGS		PSB	
Sites	m a.s.l.	G††	NG††	G	NG	G	NG	G	NG	G	NG	G	NG
MP1	1195	14630	11545	2289	2588	13800	4379	597	2090	1725	2886	3782	5772
MP2	739	15028	4080	3981	3085	2853	100	1990	1891	1592	199	9289	14630
MP3	727	19108	9156	3483	3782	1460	1990	1990	796	4644	3682	5971	3185
MP4	725	7365	9853	5673	697	995	299	1062	697	7033	7962	6104	3483
MP5	736	3483	7166	2588	2389	3317	6867	796	597	1327	1791	2057	2488
MP6	722	7564	15326	4877	1891	3583	3384	1924	1592	3848	2687	6502	3682
MP7	726	7265	12142	1493	796	5839	1194	1261	697	1062	597	3782	2886
MP8	752	6071	20303	4479	5474	3052	5374	2123	1294	5573	3981	4644	3782
MP9	697	5872	7166	2488	7962	4246	3682	3384	1592	6768	2687	1393	2189
MP10	690	5971	6967	3384	4080	4379	3981	1327	1990	2455	3782	3450	1393
MP11	689	28264	7166	1692	896	5507	1990	2521	896	2521	1194	6436	2986

† RGS = Readily Germinable Seedbank, PSB = Permanent Seed Bank.

†† NG = Ungrazed area, G = Grazed area.

Marage *et al*. (2006) reported that species richness decrease with grazing pressure. On the contrary, in accordance to our results, Heinken *et al.* (2006) at temperate forest in Germany and Malo *et al*., (2000) in Mediterranean dehesas, found an increase in the seed bank diversity under grazing.

Table 2. Analysis of variance for the total seed bank dataset of 2012, 2013 and 2014 (grazed *vs.* ungrazed areas – GLM model ($p \leq 0.05$). Year as random variable)

Source	Levels of treatment	Means	Standard error	F-ratio	P
Years	2012	6853 [a]	97.8998	493,73	†††
	2013	2622 [c]			
	2014	3861 [b]			
Grazing	G	4803 [a]	79.9349	40,03	†††
	NG	4087 [b]			
Seed treatments	PSB	3076 [b]	466.505	17,22	†††

† Means followed by the same letters within a column are not significant different ($p \leq 0.05$).

The GLM model (Table 2) shows that the seedling number was influenced significantly by the grazing regime, year and seed treatments. No significant differences were recorded between sites and for the interactions among the considered variables. According to Koc *et al*. (2013), herbivores affecting the plant community either directly or indirectly, are a crucial part of the grazing ecosystem. The same authors reported significant differences with respect to seed bank composition among grazed sites. Nevertheless, in our results, there were no differences among grazing sites with respect to the composition of the seed bank, in accordance with Peco *et al*., 1998.

IV – Conclusions

Our study found that soil seed bank size declines significantly under ungrazed conditions and that in the environmental and management conditions of our study site, the livestock pressure promotes the increase of seed bank size. In a condition of high variability of pastoral types and of their spe-

cific livestock carrying capacity, an adequate and site-specific grazing management, which combines ecological and productive aspects, is advisable. An appropriate and site-specific grazing management may represent a strategy for the conservation of resilient and biodiverse grasslands within Mediterranean oak-based silvopastoral systems.

Acknowledgments

This work was partially financed by founds FSE 2007-2013, Regional Low n° 7/2007 – Young researchers – Autonomous Regions of Sardinia. The authors wish to acknowledge Mr Daniele Nieddu, Mr Daniele Dettori, Mr Piero Saba and Mrs Maria Maddalena Sassu for their technical help.

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