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Impact of grazing on the agro-ecological characteristics of a Mediterranean oak woodland. Five years of observations at Monte Pisanu forest

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Abstract. In the Mediterranean areas, silvo-pastoralism represents a territorial management system where trees and shrubs grow together with herbs and where livestock takes advantage on such botanical association. This system still plays an important role for the socio-economic subsistence of rural populations, representing an externality against the progressive abandonment of rural areas. From an ecological point of view, a correct grazing management, related with the potential forage availability and quality, can encourage the conservation of high biodiversity. The forest of Monte Pisanu is a protected area in the Central North Sardinia and represent an interesting example of multifunctional silvo-pastoral management. The aim of this work was to contribute to this management considering, with a five-year experience, the agronomic and ecological value of the site and the impact of grazing on the agro-ecological status of the herbaceous cover. Five years of observation show that grazing activity keeps high biodiversity levels and, on the other hand, negatively impacts the pastoral value.

Keywords. Pastoral value – Specific indices – Grazing – Biodiversity.

Impact du pâturage sur les caractéristiques agro-écologiques d'un bois de chênes méditerranéens. Cinq années d'observations dans la forêt Monte Pisanu

Résumé. *Dans les régions méditerranéennes le sylvopastoralisme représente un système de gestion territoriale où les arbres et les arbustes se développent en association avec les plantes herbacées et où l'élevage profite de cette complexité. Ces systèmes jouent encore un rôle important pour la subsistance socio-économique des populations rurales, ils représentent une externalité contre l'abandon progressif des zones rurales. D'un point de vue écologique, une gestion appropriée du pâturage, liée au potentiel fourrager, à sa disponibilité et à sa qualité, peut encourager la conservation d'une biodiversité élevée, évitant des phénomènes négatifs de sous ou sur pâturage. La forêt de Monte Pisanu est une zone protégée dans le centre nord de la Sardaigne et représente un exemple intéressant de gestion sylvo-pastorale multifonctionnelle. Le but de ce travail était de contribuer à cette gestion, par une évaluation durant cinq ans des valeurs agronomiques et écologiques du site et de l'impact du pâturage sur l'état de la couverture herbacée. Cinq ans d'observation montrent que l'activité pastorale préserve la biodiversité, mais pourrait affecter négativement la valeur pastorale.*

Mots-clés. *Valeur pastorale – Indices spécifiques – Pâturage – Biodiversité.*

I – Introduction

Myers *et al.* (2000) defined Mediterranean basin as one of the main 25 hotspots of Earth biodiversity with over 25,000 vegetal species and 770 vertebrate species. Forests of *Quercus suber* L., *Quercus ilex* L. and *Quercus pubescens* Willd., widespread in the Mediterranean agro-silvo-pastoral landscape, have been forged by the livestock presence and still nowadays play an important role in the socio-economic context. Currently, many inlands are severely concerned by rural abandonment and exposed to changes of their agro-ecological functions. The main objective of this work was to assess the effects of five years grazing exclusion on agro-ecological indicators, such as Shannon Index (SH) and Pastoral Value (VP), in a Sardinian oak woodland.

II – Materials and methods

The trial was carried out during five years (2007-2011) in the Forest of Monte Pisanu (Central Sardinia, Italy), identified as Site of Community Importance (SIC). The vegetation is characterised by *Quercus ilex*, *Quercus pubescens*, *Taxus bacata*, *Ilex aquifolium, Quercus suber* and *Castanea sativa*. In this area, the grazing is rotational heavy for dairy sheep and continuous light for cattle, with an estimated livestock of 650 L.U. per year on a total forest surface of 2,000 ha. Forest grazing is commonly carry out only in less dense or open (gaps, cleared areas), with moderate to heavy stocking rates. Twenty-three representative grazed areas, located between 600 m and 1200 m a.s.l., were identified. Since 2009, a representative fenced area of 4 m x 4 m was identified into each grazed area, to follow the vegetation dynamic of the herbaceous layer in ungrazed conditions. Botanical analyses were carried out both in grazed (G) and ungrazed areas (NG). Vegetation data were collected by applying a point intercept method (Daget-Poissonet 1969) on 2 x 50 m line intersect transects in G (total counts = 200), and on 2 x 4 m line intersect transects in NG (total counts = 40). The surface recorded was about 2500 m^2 per site. For each site was determined the pastoral value (Daget and Poissonet 1969) using the following formula: VP = 0.2 x (Σ SCi x Si), were SCi is the Specific Contribution (%) to single species and Si is the Specific Index (Roggero *et al*. 2002; Cavallero *et al.* 2007). The ecological value was estimated by Shannon Index SH (Shannon, 1948).

III – Results and discussion

Around 200 species were identified over five years, mainly *therophytes*, *hemicryptophytes* and *geophytes*, referable to 34 families, mainly Graminaceae, Leguminosae and Compositae, with high presence *of Asphodelus microcarpus* Salzm. et Viv. and any endemic species as *Armeria sardoa* Spreng, *Bellium bellidioides*, *Oenante crocata* L.*, Paeonia morisii* (Viv.) Cesca, Bernardi et N.G. Passal and *Ptilostemon casabonae* (L.) Greuter.

Shannon index (Table 1) was significantly different between G *vs* NG areas, ranging from 2.49 in mp19 (2008) to 4.77 in mp3 (2007) in grazed areas and from 1.31 in mp14 (2011) to 3.82 in mp18 (2008) in ungrazed areas. Average SH differed significantly among G and NG areas, ranging respectively from 3.7 to 2.7.

Pastoral Value (Table 2) ranged from 8.1 in mp7 (2011) to 44.9 in mp20 (2008) in unfenced areas and from 12.5 in mp7 (2009) to 52.3 in mp22 (2011) in fenced areas showing inter and intra annual statistical significant differences among sites and between G and NG ($p \leq 0.05$) (Table 3).

The highest values of VP were due to the presence of perennial grasses (*Lolium perenne* L, *Dactylis glomerata* L.) and annual legumes (subclovers and medics). According with Alrababah *et al.* (2007), in fenced areas were found a high number of grazing-sensitive groups composed by high palatable species. Moreover, GLM model for SH and VP (year as random variable) exhibit that the two indicators were influenced significantly by locations of sites and grazing regime, while year influenced significantly only VP. Interactions Site x Grazing were significantly different only for SH, showing that the effect of grazing exclusion on species richness had a different impact depending on the site ecological traits. According with Daget and Poissonet (1969) and Daget and Godron (1995), the potential carrying capacity estimated in this silvo-pastoral context ranged between 1.05 LU ha^{-1} $year^{-1}$in more fertile sites and, 0.2 in more marginal sites.

Table 1. Shannon Index (SH) of the 23 observation areas

		2007	2008	2009		2010		2011	
Sites	**m a.s.l.**	**G**	**G**	**G**	**NG**	**G**	**NG**	**G**	**NG**
mp2	1172	4.03	3.13	3.20	2.66	3.56	n.a.	n.a.	n.a.
mp3	1080	4.77	4.06	4.14	1.88	4.07	n.a.	n.a.	n.a.
mp4	1195	4.09	4.02	3.76	2.58	3.93	3.35	3.87	2.88
mp6	946	4.02	4.34	4.49	3.64	4.37	3.03	4.24	n.a.
mp7	1166	3.68	4.04	3.48	2.57	3.44	2.63	3.33	n.a.
mp10	781	4.23	3.95	4.18	3.49	4.34	n.a.	4.01	n.a.
mp13	705	4.20	3.79	4.27	3.46	3.90	2.68	3.73	2.80
mp14	739	3.95	3.58	3.66	1.42	3.57	2.05	3.89	1.31
mp15	683	3.75	4.08	3.64	2.05	3.74	n.a.	n.a.	n.a.
mp17	727	4.38	3.71	3.61	2.03	3.62	n.a.	4.00	n.a.
mp18	693	4.05	4.25	4.63	3.82	4.48	3.76	4.21	n.a.
mp19	670	3.02	2.49	2.65	1.88	3.14	n.a.	3.84	n.a.
mp20	601	4.10	3.72	3.79	2.43	3.93	n.a.	3.57	n.a.
mp21	727	3.72	4.11	3.79	3.34	4.19	2.92	3.97	2.96
mp22	725	3.52	3.49	3.68	3.12	3.17	2.77	3.30	2.82
mp24	736	4.33	3.89	3.77	3.73	3.95	n.a.	4.24	n.a.
mp25	736	3.73	3.44	3.14	2.27	3.63	2.20	3.27	1.48
mp26	722	3.49	3.34	3.53	2.46	3.62	2.16	3.28	2.64
mp27	726	4.07	3.83	3.44	2.68	4.00	2.83	3.56	3.44
mp28	752	3.43	3.90	3.86	3.67	4.00	3.30	3.85	2.79
mp29	697	3.64	4.05	4.04	3.41	4.01	3.35	4.07	3.56
mp30	690	3.49	3.87	3.47	3.33	4.17	3.49	4.48	3.71
mp31	689	3.90	3.63	4.11	2.64	4.37	2.60	3.95	1.99
Average		***3.90***	***3.77***	***3.75***	***2.81***	***3.88***	***2.87***	***3.83***	***2.70***

* NG = Not grazed area, G = Grazed area.

** n.a.= Data not available (stolen or damaged fence).

IV – Conclusions

Monte Pisanu silvopastoral system, based on transhumance as an integral part of the livestock feeding calendar, represents in Sardinia, an example of pacific coexistence between livestock farmers and foresters. The current variable grazing management applied in the observed forest has opposite effects on ecological (Shannon Index) and agronomic value (Pastoral Value) of the pasture vegetation. Higher pastoral values were observed in ungrazed areas, as a consequence of the selective action of variable grazing toward the most palatable species. On the other hand, lower Shannon Indeces were found inside the exclusion cages, pointing out the positive effect of moderate to heavy grazing on biodiversity.

The high variability of pastoral types and their specific livestock carrying capacity suggests an adequate and site-specific grazing management, aimed at combining ecological and productive aspects.

Table 2. Pastoral Value (VP) of the 23 observation areas

	2007	2008	2009		2010		2011	
Sites	**G**	**G**	**G**	**NG**	**G**	**NG**	**G**	**NG**
mp2	34.2	33.0	24.3	21.0	30.1	n.a.	n.a.	n.a.
mp3	26.5	32.9	18.8	32.3	28.5	n.a.	n.a.	n.a.
mp4	17.5	20.7	9.8	18.0	22.9	19.3	15.9	41.0
mp6	17.1	19.7	16.8	26.5	17.9	22.5	13.3	n.a.
mp7	13.0	19.9	10.9	12.5	22.5	31.5	8.1	n.a.
mp10	31.9	28.2	27.9	35.3	32.1	n.a.	28.5	n.a.
mp13	28.8	30.9	26.3	37.0	35.1	40.5	29.4	36.0
mp14	25.0	25.2	25.1	22.3	21.5	21.3	17.8	21.5
mp15	38.4	30.6	34.3	37.8	38.1	n.a.	n.a.	n.a.
mp17	34.9	29.6	30.9	35.0	29.7	n.a.	30.0	n.a.
mp18	25.9	28.2	33.7	30.0	38.1	46.3	25.6	n.a.
mp19	23.0	21.7	26.7	22.0	23.5	n.a.	26.7	n.a.
mp20	40.2	44.9	26.8	30.0	41.4	n.a.	38.5	n.a.
mp21	17.9	25.8	19.8	26.8	26.9	37.0	20.8	40.8
mp22	21.5	26.2	22.1	29.8	24.2	42.0	27.9	52.3
mp24	24.9	39.1	26.0	36.0	24.4	n.a.	23.4	n.a.
mp25	19.1	27.1	23.4	17.5	21.6	21.3	25.4	26.5
mp26	27.4	36.0	27.1	37.5	26.9	39.5	29.2	39.5
mp27	17.2	26.0	19.9	25.0	22.7	22.5	24.1	36.5
mp28	24.4	29.2	29.4	31.5	30.4	28.3	26.8	22.8
mp29	16.6	25.5	21.2	28.8	21.9	25.3	23.8	33.8
mp30	22.9	28.1	24.1	24.3	28.1	34.5	27.1	30.8
mp31	23.5	25.4	28.1	30.5	31.0	25.8	24.3	24.8

Table 3. Analysis of variance for the dataset of 2009, 2010 and 2011 (grazed *vs* fenced areas) – GLM model for VP and SH. C as random variable

Source	Df	Mean Square		F-ratio		P	
		VP	SH	VP	SH	VP	SH
A: Site	22	137.5	0.9	5.4	10.8	***	***
B: Grazing	1	761.1	28.8	26.3	354.1	***	***
C: Year	2	182.2	0.1	7.3	1.0	***	n.s.
Interaction A x B	22	38.8	0.3	1.6	3.7	n.s.	***

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