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Effects of grazing on the traits of a potential fire in a Sardinian wooded pasture

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Abstract. Mediterranean rural landscapes are often characterized by a complex matrix of grasslands, open wooded pastures, shrubland and broadleaf forests, and are affected by a considerable frequency of fire ignitions. Whatever the causes and the interested landscape structure, the risk of burning is related with the fuel biomass. This paper would clear the role of grazers in reducing the fire risk within 2000 ha of a typical Mediterranean *Quercus* spp. forest, by a modelling approach, based on FARSITE simulator, able to estimate the probability of burning, and the severity of the fires. Fuel biomass samples were collected at the start and the end of the fire season in 23 representative sites, in order to define the spatial variation of the herbaceous fuel model in grazed and non grazed conditions. Ungrazed conditions were simulated placing exclosure cages in each site. The study allowed to assess the effect of the grazing abandonment on the fire behavior. Fuel reduction strategies tested by the simulator permitted to define the role of grazers in the fire prevention plan.

Keywords. Grazing – FARSITE – Fuel management.

Effets du pâturage sur les caractéristiques d'un incendie potentiel dans des prairies boisées en Sardaigne

Résumé. *Les paysages ruraux méditerranéens sont souvent caractérisés par une matrice complexe de prairies, pâturages faiblement boisés, buissons et forêts de feuillus, et sont très fréquemment touchés par des démarrages d'incendies. Quelles que soient les causes et la structure paysagère concernée, le risque d'incendie est lié à la biomasse combustible. Cet article vise à éclaircir le rôle des animaux brouteurs en vue de réduire le risque d'incendie dans 2000 ha d'une forêt typique méditerranéenne d'espèces de Quercus, par une approche de modélisation, basée sur le simulateur FARSITE, capable d'estimer la probabilité du feu et la sévérité des incendies. Des échantillons de biomasse combustible ont été collectés au début et à la fin de la saison des incendies dans 23 sites représentatifs, afin de définir la variation spatiale du modèle de combustible herbacé selon que les terrains étaient pâturés ou non pâturés. L'état de non pâturage a été simulé en plaçant des enclos de mise en défens dans chaque site. L'étude a permis d'évaluer l'effet de l'abandon du pâturage sur le comportement du feu. Les stratégies visant à réduire le combustible testées par le simulateur ont permis de définir le rôle des animaux brouteurs en matière de plan de prévention des incendies.*

Mots-clés. *Broutage – FARSITE – Gestion du combustible.*

I – Introduction

The demographic dislocation and the displacement of richest and most appealing economies to urban centers and coastal areas, are inexorably leading to the abandonment of Mediterranean inland areas, giving rise to a number of socio-economic and environmental risks (PASTOMED, 2007). According to a complex study advanced by Weissteiner *et al.* (2011), based on multi-source spatial data, abandonment is more advanced in areas of direct (open spaces in sparse

vegetation, pastures) or indirect (forests) pastoral relevance. In these conditions, the fire danger is the most relevant environmental risk, related with the biomass fuel, whose quantity is limited by the animal grazing. This paper tried to investigate the relationships between grazing and fire behaviour, using the FARSITE fire behaviour simulator (Finney, 1998) in order to map the fire probability and severity at landscape scale. The aims of this study were (i) to estimate the modifications of fuel biomass as a consequence of grazers presence and (ii) to estimate the effect of grazing on the spread and behaviour of the potential fires.

II – Materials and methods

The trial was carried out in the Forest of Monte Pisanu, Central Sardinia, Italy, during five years (2007-2011). It's a public forest, property of government since 1886, of about 2000 ha, identified as Site of Community Importance (SIC) by European Union (ITB001102 Mountain range of Marghine-Goceano). The vegetation is characterised by woods of *Quercus ilex* and *Quercus pubescens*, individuals of *Taxus bacata*, *Ilex aquifolium, Quercus suber* and *Castanea sativa*. Grazing is rotational heavy for dairy sheep and continuous light for cattle, with an estimated livestock of 650 L.U. per year.

On 23 representative areas with low tree cover density (gaps, cleared areas, thinned wood), where grazing activity is performed, reliefs on grazed fuel biomass were carried out over five years in late spring and summer; in 2009, exclosure cages of 4 m^2 were placed in each site, in order to simulate the exclusion of grazers and the consequent response of the herbage accumulation. On each site, four herbaceous biomass samples at ground level within a sample area of 0.25 m^2 site were collected. Ungrazed fuel biomass was estimated cutting the herbaceous layer in two sample areas of 0,25 m^2 within each exclosure cage. All biomass samples were dried at 80°C for 12 hours and weighted for estimating dry matter production and fuel moisture.

Potential fires were simulated identifying 30 ignition points randomly distributed across a buffer area of 10 meters round the roads. Starting from the ignition points, several simulations were conducted in order to predict the fire behaviour for the two different fuel management scenarios. We used a Geographic Information System (GIS, ArcGIS 9, ESRI Inc.) in order to manage the spatial information of the project area, and to obtain input layers needed to execute the model simulations. The grid resolution of all spatial information was 15 m. A digital elevation model (DEM) was used to produce the maps of slope and aspect required as input by the simulator. Data on wind speed and direction were provided as raster maps with a grid resolution of 50 m, as calculated by a mass-consistent model. FARSITE simulator were run using two custom fuel models for herbaceous vegetation, respectively under grazed and non grazed conditions. The data provided by FARSITE (fire perimeter, rate of spread, fireline intensity) were used in order to describe the fire behavior.

III – Results and discussion

The identified sites are located in an altitude comprised between 600 m and 1200 m a.s.l.. 18 of 23 are located within the altitude range 600-800 m a.s.l. (Table 1). Data of ungrazed and grazed biomass (dry matter, t ha^{-1}) are expressed as the average values in, respectively, three and five years of the trial. As expected, fuel biomass accumulated within the exclosure cages was higher than the grazed conditions. On average, ungrazed biomass resulted of 2,5 t ha^{-1} of dry matter, ranging between 0.7 up to about 8 t ha^{-1}, with a wide variability due to the inter-annual (rainfall distribution and totals) and intra-site (microhabitat conditions) sources of variation. Average grazed biomass was about 1 t ha^{-1}, tendentiously lower in the top position sites ($r = -0.67$ between altitude and grazed biomass, $n = 23$). Regarding the assessment of fire probability and severity, the fire information provided by FARSITE were transformed into raster format and reclassified in order to provide, for the whole extension of the project area, (i) the number of

times in which the simulated fires affected each pixel of the project area (burn probability), and (ii) the distribution of the values of both rate of spread and fireline intensity for the different scenarios. In the ungrazed scenario (Fig. 1A) maximum probability of fire propagation (15-25%) are referred to two large areas on the north west and south east flank (4800 ha); several sections of the latter area (about 4000m) regarded a wildland urban interface. Strong reduction (-86%) of the area covered by the same classes was observed in the grazed scenario (Fig. 1B), also characterized by a strong reduction (-77%) of the burned area. The rate of spread (ROS, m/min, Fig. 1C, 1D) was characterised by a general lower magnitude in the grazed scenario, where the highest values (>36 m/min) can be observed only in the north-west upland and in the steeper areas near the south-east flank. Regarding the fireline intensity, the grazed scenario (Fig. 1E, 1F) was characterised by about the 90% of the burned area with fireline intensity values under 1700 kw/m, which can be considered a critical threshold in order to establish effectiveness and feasibility of the methods of direct attack.

Table 1. Average values of fuel biomass (dry matter, t ha^{-1}) in the three years of the trial. Each value represents the mean of the 4 samples per site

Site	Coordinates		Altitude	Fuel biomass (t ha^{-1})			
	Latitude	Longitude		Ungrazed		Grazed	
				Mean	StDev	Mean	StDev
MP2	40°25 463	9°00 395	1172	2.4	0.78	0.3	0.27
MP3	40°25 738	9°00 461	1080	5.3	1.94	0.5	0.73
MP4	40°25 192	9°00 186	1195	3.3	1.66	0.7	0.58
MP6	40°25 477	8°58 982	946	1.3	0.17	0.7	0.43
MP7	40°25 114	9°00 056	972	0.7	0.56	0.3	0.22
MP10	40°25 887	8°58 250	781	3.8	1.94	0.8	0.39
MP13	40°26 285	8°57 875	705	3.9	2.09	0.8	0.5
MP14	40°26 287	8°57 976	739	7.9	7.85	0.8	0.65
MP15	40°26 562	8°57 576	683	1.8	0.59	1.7	0.88
MP17	40°26 605	8°58 052	727	1.5	0.45	0.5	0.32
MP18	40°26 809	8°57 614	693	2.9	0.35	1.3	1.12
MP19	40°26 936	8°57 276	670	2.2	0.17	1.2	0.78
MP20	40°27 027	8°57 815	601	1.2	0.64	1.1	0.63
MP21	40°27 239	8°57 296	727	2.8	0.82	1.1	0.55
MP22	40°27 509	8°57 511	725	2.2	0.88	1.6	0.93
MP24	40°27 153	8°56 812	736	2.7	1.04	1.3	0.63
MP25	40°27 432	8°56 505	736	2.0	0.77	1.7	0.91
MP26	40°27 625	8°57 214	722	2.1	0.6	1.2	0.64
MP27	40°27 628	8°56 613	726	1.8	1.59	1.1	0.59
MP28	40°28 069	8°56 485	752	2.8	0.59	1.3	0.75
MP29	40°28 412	8°56 548	697	2.4	1.81	0.8	0.4
MP30	40°28 754	8°56 573	690	1.5	0.75	0.9	0.32
MP31	40°28 814	8°56 435	689	1.5	0.60	1.3	0.62

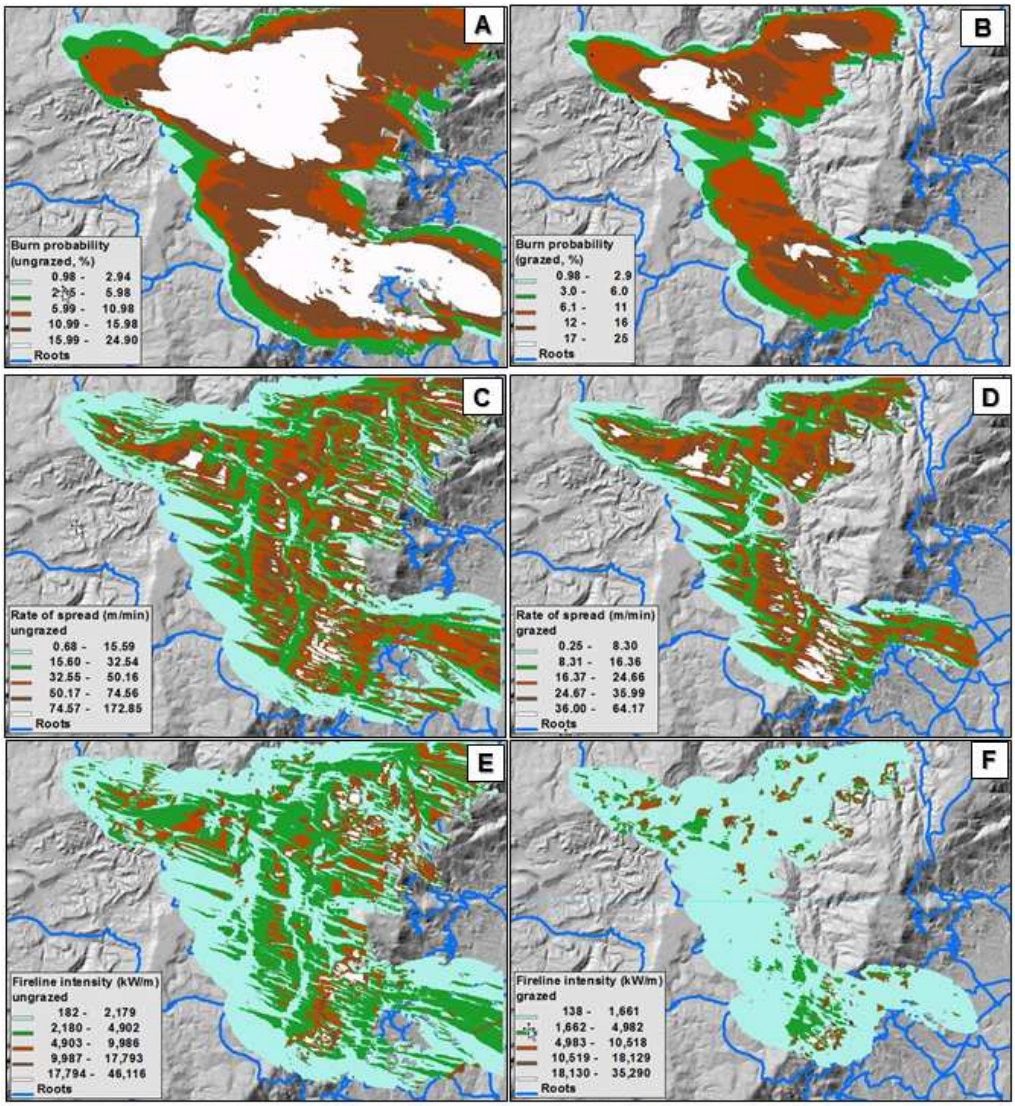

Fig. 1. Values of the propagation probability, rate of spread and fireline intensity calculated for grazed (A, C, E) and ungrazed (B, D, F) conditions by FARSITE simulator.

IV – Conclusions

The results provided by FARSITE simulator in the high natural value forest environment of Monte Pisanu, highlights the strategic importance that can be attributed to the control of herbaceous biomass in fire prevention and management. In Sardinia, as well as in many other Mediterranean forest and sylvopastoral systems, fire prevention is carried out only through the sighting and the timely involvement of fire-fighting interventions, in an attempt to contain the caused damages. In contrast, results obtained from the data collected during the trial, clearly show that the pastoral activity, playing an active role in limiting the fuel biomass, has a positive

impact in containing the fire danger level. The use of pastoral activities regulated and weighted on the real potentialities of the natural pastures within the forest areas, could be a valuable support in the prevention of forest fires, involving farmers in the garrison and prevention plans of the area, possibly supporting this role with specific subsidies

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