Effect of regional conditions on post-fire vegetation restoration rate in Mediterranean rangeland ecosystems.

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Abstract

After fire in natural ecosystems begins the secondary procession, which in certain time restores the vegetation to the succession stage, as it was before the fire occurred. This natural restoration of vegetation depends mainly on the type of vegetation, the climatic and soil conditions and fire intensity. The restoration rate is the main factor for their evolution. The purpose of this research was to evaluate the rate of restoration of vegetation on rangeland ecosystems after fire and to study the probability of reducing the time of grazing forbiddance. The research was conducted in burned forest areas of the prefecture Lakonia and Ileia 3 years after the fire of year 2007. In this area two ecotopes were selected: 1) shrubland and 2) Allepo pine woodland, in which the following parameters were measured: a) the soil cover with vegetation, b) participation of species in the composition of vegetation, c) the total annual production, d) the total height of the dominant shrubs e) the amount and the height of seedlings of *Pinus halepensis*. Our results indicated, that three years after the fire all the ecotopes had soil cover with vegetation greater than 75%, which means that the restoration of vegetation has created foliage cover able to protect the soil from erosion. Furthermore the restoration rate of vegetation in both shrublands and Aleppo pine woodlands has created a dynamic development process such as to ensure their stability.

Keywords: drought index, post fire restoration, rangelands, grazing.

Introduction

The Mediterranean-type vegetation is one of the world's major fire-prone biomes (Capitanio and Carcaillet, 2008). In areas where this type of vegetation occurs, fire is a crucial process controlling the vegetation dynamics and structure and the post-fire regeneration processes are highly dependent on the pre-fire vegetation (Pausas et al. 2008). The behavior of plant communities and plant cover can regulate and control the soil processes in the post-fire period, due to its influence on organic matter inputs, soil structure, soil erosion risk and hydrologic processes (Granged et al. 2011). The restoration rate is the main factor for their revolution. The lawmaker anticipates the forbiddance of grazing in burned areas. However, in rangelands ecosystems with high capacity, long-term forbiddance of grazing, creates accumulation of large quantities of dry biomass, increasing in this way the risk of new fires. The purpose of this research was to

evaluate the rate of restoration of vegetation on rangelands ecosystems after fire and to study the probability of reducing the time of grazing forbiddance.

Materials and Methods

The research was conducted in burned forest areas of the prefecture Lakonia, 3 years after the fire of year 2007. In this area two ecotopes were selected: 1) shrubland, in which the dominant shrub species were *Quercus coccifera, Phyllirea latifolia,Pistacia lentiscus and Arbutus unedo* 2) Aleppo pine woodland, in which the dominant shrub species of the understory were: *Quercus coccifera, Pistacia lentiscus* and *Arbutus unedo*. Totally 6 range units were selected in each prefecture: 3 shrublands and 3 Aleppo pine woodlands in which the following parameters were measured: a) the soil cover with vegetation, b) participation of species in the composition of vegetation with the line point method (Cook and Stubbendieck 1986) c) the total annual production with quantrants 50 X50, d) the total height of the dominant shrubs e) the amount and the height of seedlings of *Pinus halepensis*, in fifteen quantrants 50 x 50 cm . In each plot the seedlings were classified into two classes according to their height (20-50cm and 50-100cm). As regeneration index we defined the number of seedlings per square meter. From the data, was calculated the grazing capacity and the grazing stocking rate expressed in small monthly animal units for 9 months grazing, as such as and the rangeland footprint (grazing stocking rate/grazing capacity). Based on the total monthly rainfall and the average monthly temperature during the three years after fire, we calculated the drought index de *Martonne,* according to the formula: J=2P/T+10, where T is mean annual temperature and P is mean annual amount of precipitation, One-way ANOVA was used to compare the means in two ecotopes with the LSD posthoc test (Kinnear and Grey 2008).

Results and discussion

The change of drought index values during the period (2008-2010) in Lakonia and Ileia prefecture is shown in Figure 1. The climate of Lakonia is drier than Ileia prefecture since the values of drought index were < 20 for longer period during the year, which indicates long drought periods (Koleva and Alexandrov 2008). Consequently, Ileia prefecture had more favourable climatic conditions (temperature, rainfall) for vegetation growth than Lakonia. In order to evaluate the effects of regional climatic conditions on the rate of vegetation restoration after fire, total soil cover with vegetation

and total annual forage production was measured (Table1). Total vegetation soil cover and annual forage production of Ileia prefecture were significantly increased, by 16% and 49.5% respectively, in contrast to Lakonia prefecture.

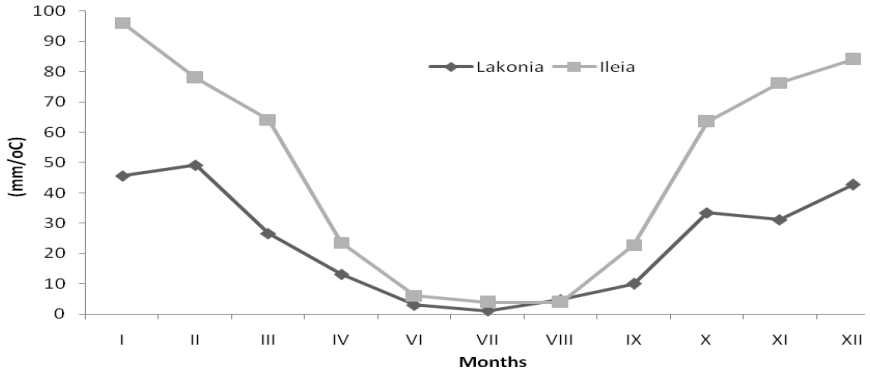

Figure 1. Mean drought index values de Martonne (J) of Lakonia and Ileia prefecture during 2008-2010 (3 years after fire).

Table 1. Total soil cover with vegetation in 2010 (%), total annual forage production in 2010 (kg/ha) and mean drought index value de Martonne (J) (year 2008-2010), in burned areas of Lakonia and Ileia prefecture.

Prefecture	Drought index (2008-2010)	Total annual forage production (kg/ha)	Total soil cover with vegetation (%)
Lakonia	18.4	2755 b*	79.8 b
Ileia	37.9	4119 a	92.4 a

*Letters in the same row indicate differences at 0.05 significant level using LSD posthoc test

Furthermore, three years after fire, in all ecotopes vegetation cover was greater than 75% whereas annual production of woody species in shrubland and Aleppo pine ecotypes of Ileia prefecture was significantly higher by 89.3 and 86.1% respectively, than Lakonia prefecture ones (Table 2).The rapid recovery of the vegetation is in line with other studies in the Mediterranean region (Van der Merwe and Van Rooyen 2011). These results indicate that

drought index affects vegetation soil cover and annual forage production with higher index values accelerating the post fire regeneration rate.

Table 2. Annual woody and herbaceous forage production (kg/ha) and vegetation soil cover (%) in different ecotypes of burned areas in Lakonia and Ileia prefecture, in 2010.

Prefecture	Ecotope	Annual production of woody species	Annual production of herbaceous species	Vegetation soil cover (%)
Lakonia	Shrubland	1546 d	910.6 a	75.0 d
	Aleppo pine	2018 c	1036 a	84.5 c
Ileia	Shrubland	2926 b	892 b	90.0 b
	Aleppo pine	3755 a *	766 b	95.5 a

*Different letters in the same row indicate differences at 0.05 significant level using LSD posthoc test

In Mediterranean ecosystems, where water availability is a limiting factor for the vegetation (Archibold 1995), regional patterns of vegetation structure and composition are determined by a dryness gradient. Thus, vegetation cover is higher in areas with higher water availability than in drier areas (Lloret et al. 2005).

Rangeland footprint in woodland and shrubland of Ileia prefecture was lower or near one (Table 3), indicating that three years after fire period the extent of vegetation regeneration in these ecotypes, could permit livestock grazing. In Lakonia prefecture the rangeland footprint was bigger than one in all ecotopes and was estimated that it will probably take two more years to restore the vegetation to a degree to permit grazing. In the contrary, the lower values of rangeland footprint of Ileia prefecture permit the grazing in all ecotopes three years after fire. Grazing will contribute to Aleppo pine seedlings development, because of reducing the competition with annual herbage vegetation. Annual herbaceous species exerted a detrimental effect on seedlings density in both prefectures (Table 4), whereas increased vegetation cover reduced seedling density, mainly due to interspecific resource (water and nutrient) competition. Recent studies have been reported same results investigated post fire regeneration of *Pinus halepensis* stands in Mediterranean area (Prevosto and Ripert 2008).

Table 3. Mean grazing stocking rate and grazing capacity (goats and sheeps/ha / 9 months grazing) in each ecotype of burned areas of Lakonia and Ileia prefecture in 2010.

Prefecture	Ecotope	Grazing capacity	Grazing stocking rate	Rangeland footprint (Grazing stocking rate/Grazing capacity)
Lakonia	Shrubland	1.5	3.1	2.0
	Aleppo pine	1.6	2.3	1.4
Ileia	Shrubland	2.0	2.2	1.1
	Aleppo pine	1.8	1.3	0.72

Table 4. Height class distribution and regeneration index of *Pinus halepensis* seedlings (seedling/ha), annual herbaceous species composition in vegetation and mean shrub height (cm) of Aleppo pine burned areas of Lakonia and Ileia prefecture in 2010.

Prefecture	Ecotope	Seedlings 20-50 cm (seedling/ha)	Seedling height 50-100 cm (seedling/ha)	Annual herbaceous species composition (%) in vegetation	Mean shrub height (cm)
Lakonia	Aleppo pine	69330	21330	9.6	81.0
		37330	8000	11.7	81.0
		32000	2660	12.0	73.3
Ileia	Aleppo Pine	79578	39591	13.5	120.0
		41670	65120	17.0	106.0
		53266	18667	27.3	142.7

Conclusions

Drought index affected post fire restoration process. Three years after the fire all the ecotopes in both prefectures had soil cover with vegetation higher than 75%, which means that the restoration of vegetation has created foliage cover able to protect the soil from erosion. Based on regeneration index values the Aleppo pine regeneration was satisfactory.

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