Forest Fire Research & Wildland Fire Safety, Viegas (ed.)
 ISBN 90-77017-72-0

Plant species diversity in a post-fire successional gradient in Marmaris National Park, Turkey

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Keywords: post-fire succession, species richness, species diversity, Turkey

ABSTRACT: Species diversity is one of the components of biodiversity, with genetic diversity and ecosystem diversity. The plant species of fire-prone communities of Mediterranean Basin have some adaptive traits to survive after a fire, and these communities can regenerate in a short period of time. We studied plant diversity in a postfire successional gradient in Marmaris National Park, Turkey. Species richness values and Shannon's diversity indices (*H'*) were determined for four study sites reflecting different successional stages (a 1-yr old, a 5-yrs old and a 21-yrs old site, and a control site which had not been burned for 45 yrs at the beginning of the study). Mean species richness was relatively low in one-yr old site, whereas total species richness was higher than other study sites. This was due to opportunistic species found only at the beginning of sampling, but not found at the later period. Shannon's *H'* values were significantly ($P<0.001$) lower than other sites. The high density of two *Cistus* L. species was responsible for this low *H'* value even if total species richness was high in one-yr old site. The non-significance of *H'* values ($P>0.05$) between study sites except for one-yr old site, indicated that species diversity changed only in the first postfire years and did not change during the later postfire years, so the plant community can regenerate in a short period of time. These results on species richness and species diversity pointed out a rapid postfire recovery of *Pinus brutia* Ten. ecosystems in Marmaris National Park, Turkey. If this rapid recovery combines with the knowledge on adaptive traits of plant species of *Pinus brutia* ecosystems, it can be suggested that fire may be an important tool for management of such fire-dependent ecosystems and that the presence of some opportunistic species that prefer postfire environments may depend on fires.

1 INTRODUCTION

Fire is an important ecological factor shaping Mediterranean-type ecosystems (Trabaud, 1994) and plant communities found in these areas have many adaptive or pre-adaptive traits to survive after a fire (Keeley, 1995; Thanos, 1999).

The "succession" term classically depends on definitions including "changes in species composition of a community with a strict period of time" (Odum, 1969; Finegan, 1984; Şişli, 1996). But, postfire succession in Mediterranean-type ecosystems does not fit this common definition on which based successions in old-fields. In general, there is not an important change in species composition of the plant community during postfire succession in such fire-prone areas. In contrast, the species found in the area before fire generally recover rapidly and in a very short period of time, the species composition returns its initial (prefire) composition (Westman, 1981; Arianoutsou-Faraggitaki, 1984; Moravec, 1990; Türkmen et al., 1995; Herranz et al., 1996; Trabaud, 2000). This successional process is expressed as a different term: auto-succession (Zedler, 1981; Herranz et al., 1996; Vallejo, 1999). Auto-succession is actually the regeneration of prefire communities by reproductively with their dormant seeds or by vegetatively with their underground organs (Whelan, 1995). Auto-succession proceeds with changes in abundances and covers of species rather than with changes in species composition of the community (Trabaud, 1994; Lavorel, 1999).

Species diversity is one of the components of biodiversity, with genetic diversity and ecosystem diversity (Hunter, 1996). Several species diversity measures have been developed from species richness, the simplest one, to Simpson's, Shannon's and Brillouin's indices (Krebs, 1989). These indices had been used in many kinds of successional studies such as in intertidal communities (McKindsey and Bourget, 2001), in old-fields (Nicholson and Monk, 1974), after clear-cuts (Elliott et al., 1997), and in postfire plant (Shafi and Yarranton, 1973; Herranz et al., 1996) and mammalian (Haim et al., 1996) successions. The diversity indices principally depend on number of species and abundances of each species in a certain community (Boeken, 2001).

Although lots of studies on postfire succession and postfire environments have been done in the western (Trabaud et al., 1985; Moravec, 1990; Martinez-Sanchez et al., 1997; Silva and Rego, 1999) and the eastern (Thanos et al., 1989; Thanos and Marcou, 1991; Kazanis and Arianoutsou, 1996; Schiller et al., 1997; Eshel et al., 2000; Spanos et al., 2000) parts of the Mediterranean Basin, there are relatively less study in Turkey (e.g., Peşmen and Oflas, 1971; Eron and Gürbüzer, 1988; Türkmen et al., 1995; Tavşanoğlu, 2002).

The aim of the present study was to show changes in species diversity during postfire succession in Marmaris National Park, Turkey, where was an area had not been studied by means of fire ecology until recent years.

2 METHODS

The study was carried out at Marmaris National Park which is located in the southwest of Turkey. The area had a typical Mediterranean climate with dry summers and wet winters, and was mostly covered by *Pinus brutia* Ten. forests.

In order to construct a successional gradient, it was selected three study sites which had been burned in different years (in 1999, 1995 and 1979) and a study site that had not burned for a long time period (at least 45 yrs) as a control. The study sites were found on the same geological material (ophiolithic rocks), and located very close to each other (1999 site: 36°50'11"N, 28°18'10"E; 1995 site: 36°51'16"N, 28°17'14"E; 1979 site: 36°49'37"N, 28°19'34"E; Control site: 36°50'47"N, 28°17'24"E). The study sites were at least 1 ha in size.

Randomly placed forty 1x1 m plots were used to determine species compositions of the study sites. Individuals of plant species were counted in each plot. The study was conducted from August 2000 to September 2001 by monthly. Nomenclature follows as in Davis (1965-1985).

Species richness, which is the simplest diversity measure (Krebs, 1989; Brower et al., 1990) were determined for each study site both as mean species richness and as total species richness. A more complex measure of diversity, Shannon index (H') (Krebs, 1989; Zar, 1996) were also calculated (Eq. 1).

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i \qquad \textbf{(Eq 1)}$$

where, H': Shannon's index of species diversity, p_i: proportion of total sample belonging to ith species, s: number of species.

Non-parametric Kruskal-Wallis test (Zar, 1996) was used to test whether there were significant differences between the mean H' values and the mean richness values of study sites reflecting different successional stages. Multiple comparisons of study sites were made by Q statistics described by Zar (1996).

3 RESULTS

Total number of species detected during the study was 55, whereas only 18 of them were found all of the study sites. It was detected that 27 species from 1995 site (75% of found in this site), 21 species from 1979 site (66% of found in this site) and 24 species from control site (70% of found in this site) were also found in 1999 site.

Table 1. Mean species richness (MSR±SE), total species richness (TSR) and Shannon index values (*H'*±SE) for study sites. Different superscript letters point out significant differences between study sites.

	Study sites				
	1999	1995	1979	Control	Statistics
MSR	17.0 ± 1.15^{a}	23.6 ± 1.05^{b}	22.0 ± 1.40^{ab}	20.3 ± 1.28^{ab}	**
TSR	41	36	32	34	
H'	2.13 ± 0.09^{a}	3.06 ± 0.08^{b}	3.55 ± 0.05^{b}	3.02 ± 0.18^{b}	***

**: P<0.01, ***: P<0.001

Mean species richness (MSR) value of 1999 site was relatively lower than other sites, moreover this relationship statistically significant between 1999 and 1995 sites (Q=3.422, P<0.01). But there was no significant difference in MSR values between 1995, 1979 and control sites, and between 1999 site and other sites, either (Table 1).

Contrary to the lower MSR value in 1999 site, the total species richness (TSR) value was relatively higher in this site, while other sites had more similar TSR values.

Shannon indices values (*H'*) were significantly different between study sites (χ^2=24.3, P<0.001), and in 1999 site, *H'* was significantly lower than other three study sites (Table 1, 1999-1995: Q=3.023, P<0.01; 1999-1979: Q=4.594, P<0.001; 1999-control: Q=2.757, P<0.05). But there was no significant difference between *H'* values of other three sites.

Number of shared species between study sites and number of specific species to study sites were shown in Table 2. There were 13 species specific to 1999 site and 10 of them were only found in the beginning of the sampling (in August 2000 and September 2000; first year after fire), but at the later period of time these species was disappeared (including August and September 2001).

Table 2. Number of shared species between study sites and number of species specific to sites.

	Study site			
Study site	1999	1995	1979	Control
1999	13*	27	21	24
1995	-	1*	26	29
1979	-	-	3*	27
Control	-	-	-	0*

* number of specific species to study site

4 DISCUSSION

Since difference in species richness is scale-dependent (Pausas et al., 1999), comparison of these results with other studies was difficult. Rather, richness values were only used to making comparisons between our study sites.

The presence of 10 opportunistic species which was found in the first year of succession but disappeared after this period was responsible to relatively higher TSR and lower MSR values of the

1999 site. These species were only found in the beginning of the study, so they had been took into account in the TSR estimation directly, but since they were found only two (or some of them, one) samples, mean values were lower in the MSR estimation. Being not found these species in the samplings conducted in the same months of the next year demonstrated that they had been eliminated.

Similar species compositions of all study sites except for these opportunistic species suggested that after these opportunistic species eliminated in a short period of time, the species composition returned its initial (prefire) condition. This conclude on species richness are in agreement with other studies done in postfire areas of Mediterranean Basin (Türkmen et al., 1995; Herranz et al. 1996) and this may be a common event for this fire-prone region.

Postfire regeneration of seeder species generally occur by mass germination in the first rainy season after fire in Mediterranean region (Keeley, 1995; Skourou and Arianoutsou, 1998). This event was also liable for the 1999 site where two *Cistus* species (*C. salviifolius* L. and *C. creticus* L.) germinated massively and reached very high densities (Tavşanoğlu, 2002).

For Shannon diversity index, it could be said that if abundance of species distribute evenly, there will be high species diversity, whereas if a few species have most of the total abundance, the species diversity will be low (Şişli, 1996; Zar, 1996). This was the main reason of the lower H' value in the 1999 site. With decreasing abundance of *Cistus* species (Tavşanoğlu, 2002), species diversity increased in later postfire years (that is, in 1995, 1979 and control sites). The non-significance of H' values ($P>0.05$) between study sites except for 1999 site indicated that species diversity changed only in the first postfire years and did not change during the later postfire years, so the plant community can regenerate in a short period of time.

These results on species richness and species diversity pointed out a rapid postfire recovery of *Pinus brutia* ecosystems in Marmaris National Park, Turkey. If this rapid recovery combines with the knowledge on adaptive traits of plant species of *Pinus brutia* ecosystems (Thanos and Georghiou, 1988; Neyişçi, 1993; Thanos, 1999), it can be suggested that fire may be an important tool for management of such fire-dependent ecosystems and that the presence of some opportunistic species that prefer postfire environments may depend on fires.

ACKNOWLEDGEMENTS

We thank Sinan Kaynaş for his assistance in the field. We also thank National Parks and Game-Wildlife General Directorate of Turkey to obtain places to stay in Marmaris. This study was supported by Hacettepe University Research Foundation (project no: 00.02.601.005).

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