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Effect of Forest Fires on Tree Diversity and some Soil Properties

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ABSTRACT

The effect of forest fire was studied after one year in three natural forests in Al Baha region (south-west Saudi Arabia). Three sample plots (100 m^2 each) were selected randomly inside the burned and the immediately neighboring unburned area in each forest (Al Hilia, Al Kahla & Ragdan). The effect of fire on tree species recovery, regeneration and some soil physical and chemical properties was investigated. Regeneration of *Acacia origena* increased significantly after fire and dominated the burned areas. Most of the trees in these areas either resprouted completely or partially. In contrast, *Juniperus procera* was very sensitive to fire and most burned trees failed to recover or regenerate. *Olea* spp., were intermediate in their reaction to fire, but generally they were negatively affected by fire in terms of recovery and regeneration. Fire had no effect on soil texture. Soil pH increased significantly, whereas (EC) significantly decreased in the burned sites as compared to unburned areas. Organic matter and total N decreased significantly in the burned areas, whereas available P and K increased significantly after fire. Micronutrients such as Mo, Co, Ni and Pb, varied in their response to fire and no pattern was recorded. It appears that *A. origena* might succeed other associated tree species after fire. © 2011 Friends Science Publishers

Key Words: *Acacia origena*; Forest fire; *Juniperus procera*; *Olea* spp. Regeneration; Soil properties

INTRODUCTION

Deforestation and forest fires in the tropics played a significant role in increasing emission of gases (Watson *et al*., 2000). Fire resulted in disturbance of many forest lands depending on its severity and forest composition (Rydgren *et al*., 2004; Lecomte *et al*., 2005). Severity and extent of forest fires had a significant effect on seeds and regeneration (Greene *et al*., 2004; Peters *et al*., 2005). Fire leads to burning of organic matter and this affects the nutrient status of soil for sometime (Hart *et al*., 2005; Lecomte *et al*., 2005). On the other hand, fire modifies the ecosystem for short or long term and some biota may be adapted to these changes in the ecosystem (Nguyen-Xuan *et al*., 2000; Rydgren *et al*., 2004). In some instances fire may be used for forest management purposes such as prescribed burning (Bergeron *et al*., 2002).

It has been stated that logging after fire might have a considerable long term effect on vegetation and diversity in natural forests (Fraser *et al*., 2004; Kurulok, 2004). Ellsworth and Mcomb (2003) suggested that open canopy increased fuel amount that encouraged moderate fires, which in turn favored light demanders such as eastern oak species. Controlled burning and thinning are increasingly used to manage succession in central hardwood oak forests (Franklin *et al*., 2003). Spatial fire distribution has been widely used to categorize fire regimes (Cui & Perera, 2008). Frequent and severe fires commonly result in degradation of soil (Anderson *et al*., 1981). Nevertheless, light fires encourage accumulation of litter on the surface of the soil (Legleiter *et al*., 2002; Wondzell & King, 2003). Forest fires threatened wild endangered species in Indonesia (Whitehouse & Mulyana, 2004). Fire is capable of exerting serious effects on soil properties (Bauhus *et al*., 1993; Creighton & Santelices, 2003; Giacomo, 2005; Ekinci, 2006).

The objective of this study was to investigate the impact of forest fire on tree species diversity and its effect on some soil physicochemical properties in three natural forests in Al Baha region in the south west of Saudi Arabia.

MATERIALS AND METHODS

The study area: The study was carried out in three locations in Al Baha region (south west Saudi Arabia), one year after forest fires as follows: Southern Al Baha: Al Hilia forest (N19.48864 – E41.42058, 2100 m a.s.l.); Middle Al Baha: Ragdan forest (N20.02144 – E041.43806, 2260 m a.s.l.) and Northern Al Baha. Al Kahla forest (N20.27976 – E041.23758, 2296 m a.s.l.). Description of the study sited in terms of species, density, average height and understory was provided in Table I. Most of the soils in the study areas are sandy loam or loamy sand. Al Baha region falls within the semi arid climate, where the mean annual rainfall was 403 mm, mean maximum temperature 29°C and mean minimum temperature 7°C.

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Effect of fire on regeneration: In each location, three sample plots (100 m^2 each) were selected randomly inside the burned and the immediately neighboring unburned area in each forest. The frequency of burned trees, resprouted trees, and the number of seedlings/ha were determined in each sample plot.

Effect of fire on soil physicochemical properties: In each forest, one hectare was divided into 100 plots of 100 m^2. Ten plots were chosen for the collection of soil samples at three depths: 1–10, 10–20 and 20–30 cm. Soil samples were taken approximately one year after the fire and from the neighboring unburned plots in the same forest. A Dutch auger was used to collect soil samples which were then kept in plastic bags and sent immediately to the soil analysis laboratory of the Soil Department, King Saud University, Saudi Arabia. Samples were analyzed for soil texture, electric conductivity, pH, organic matter, and major and micronutrients including N, P, K, Mo, Co Ni and Pb. Soil properties were compared between burned and unburned neighboring plots in each of the three forests under investigation.

Statistical analyses: The data was analyzed for variance analysis (ANOVA) and means were separated by LSD test of significance using SAS statistical package (SAS, 1997).

RESULTS

Burning and resprouting: It is apparent that *Juniperus procera* was most susceptible to forest fire as compared to *Acacia origena*. In Al Hilia forest, 91.7% of Juniper trees were burned and failed to recover, and only 8.3% were partially burned and recovered (Table II). A tree was considered recovered when it resumed any vegetative growth after fire. As for *A. origena*, 70% were affected by fire and resprouted, and 30% were partially burned and resprouted. Although *Olea* spp., were affected by 100%, all trees resprouted in Al Kahla forest (Table II).

Regeneration of trees: It is evident that fire had encouraged regeneration of *A. origena*, whereas *J. procera* failed to regenerate in burned sites in all forests investigated (Table III). *A. origena* recorded the maximum regeneration in the three forests studied (243, 312 & 189 seedlings/ha, respectively). As for *Olea* spp. the trend was similar to *J. procera*, but the species regenerated more successfully in Al Kahla forest. Generally, fire also encouraged regeneration of *Dodonaea viscose* (herb). For instance, it increased from 20 plants/ha to 37 plants/ha in the burned and normal sites in Al Kahla forest, respectively.

Soil texture and organic matter: Fire did not affect soil texture and this was indicated by the fact that sand, silt and clay (%) were not significantly different when burned locations were compared with normal ones in Al Hilia Forest. Soil organic matter significantly ($P \leq 0.05$) decreased from 9.5 to 3.71 g kg^{-1} after fire at 1-10 cm of soil surface (Table IV). In Ragdan forest, soil texture was not significantly affected by fire. However, organic matter was significantly ($P \leq 0.05$) reduced from 6.3 to 2.2 g kg^{-1} after fire at 1-10 cm of soil surface. Similarly, sand, clay and silt contents were not significantly ($P > 0.05$) different between burned and normal sites in Al Kahla forest. Organic matter was significantly ($P \leq 0.05$) reduced from 8.41 to 5.4 g kg^{-1} after fire at 1-10 m cm soil depth (Table IV).

Soil electrical conductivity and pH: Soil pH increased significantly ($P \leq 0.05$) from 7.34 to 8.46 after fire at 1-10 cm soil depth in Al Kahla forest. Electric conductivity (EC) significantly ($P \leq 0.05$) decreased from 2.13 in unburned sites to 1.1 dS m^{-1} in burned sites. The trend was similar in Ragdan forest, where soil pH and EC increased and decreased significantly ($P \leq 0.05$) after burning, respectively. Also a significant ($P \leq 0.05$) increase in soil pH and a decrease in EC were recorded after fire in Al Hilia forest (Table V).

Soil Nutrients

Al-Hilia forest: Available K significantly increased at 1-20 cm after the fire, whereas the differences were not significant ($P > 0.05$) at 20-30 cm of soil depth between burned and normal sites (Table VI). Similarly, available P significantly ($P \leq 0.05$) increased after fire from 12.67 mg kg^{-1} to 29.8 mg kg^{-1} at 1-10 cm soil depth. Total N significantly decreased from 34.5 mg kg^{-1} in unburned sites to 27.66 mg kg^{-1} in burned sites at 1-10 cm soil depth. For the rest of the soil depths the differences were not significant ($P > 0.05$) when burned and normal sites were compared (Table VI). Mo increased from 0.15 mg kg^{-1} to 0.21 mg kg^{-1} after the fire and it was maximum at 1-10 cm in the burned site. Similarly, Co and Pb increased significantly ($P \leq 0.001$) from 0.03 mg kg^{-1} to 0.63 mg kg^{-1}, and from 0.23 mg kg^{-1} to 0.54 mg kg^{-1}, respectively at 1-10 cm after fire. However, there was a significant ($P \leq 0.05$) change in Ni only at 20-30 cm of soil surface from 0.12 mg kg^{-1} to 0.21 mg kg^{-1} after fire (Table VI).

Ragdan forest: Available K increased significantly ($P \leq 0.001$) in the burned sites from 137.67 to 202.33 mg kg^{-1} at 1-10 cm of soil surface (Table VI). There was no significant difference ($P > 0.05$) between other soil depths tested in burned and normal sites. Similarly, there was a significant difference ($P \leq 0.05$) in available P, which increased at 1-10 cm of soil depth in the burned sites. However, total N decreased significantly ($P \leq 0.05$) after fire from 45 to 34 mg kg^{-1} (Table VI). Considering the minor nutrients, although significant ($P \leq 0.05$) differences were recorded between burned and normal sites, however no particular pattern was observed (Table VI). There was no significant ($P > 0.05$) difference in Ni at all soil depths in burned and normal sites.

Al Kahla forest: Total N significantly ($P \leq 0.05$) decreased at 1-10 cm soil depth in burned sites (Table VI). Both P and K increased significantly ($P \leq 0.05$) in the burned sites at 1-10 cm of soil depth (3.87 to 5.32 mg kg^{-1} & 140 to 188.75 mg kg^{-1}, respectively). Mo, Pb, Ni and Co indicated no significant differences ($P > 0.05$) between burned and normal sites (Table VI).

Table I: Plant community in the study areas

Tree Species	Density/ha	Mean Height (m)	Crwon Coverage %	Understory	Density/ha	Fire Intensity (kW/m)
Al Hilia Forest						
J. procera	850	3.6	23	*Felicia dentate*	23	920
A.origena	330	4.2	34	*Felicia abyssinica*	12	
				Psidia punctulatat	15	
				Phagnalon scalarum	8	
				Achillea biebersteini	5	
Al Kahla Forest						
J. procera	938	4.2	24	*Dodonaea viscosa*	20	680
A.origena	567	3.7	11	*Conyza bonariensis*	6	
				Pulicaria crispa	8	
				Phugnalon spp	7	
				Conyza stricta	11	
				Felicia dentate	10	
Ragdan Forest						
J. procera	768	4.8	32	*Picris* spp.	27	1440
Olea spp.	156	3.7	22	*Blumea graiepina*	20	
				Crepis foetida	12	
				Conyza incana	9	
				Conyza stricta	11	
				Felicia dentate	13	
				Achillea biebersteinii	14	
				Calendula arvensis	8	

Table II: Tree recovery after fire

Location	Species	No. of trees	BR	BNR	PBR
Al Hilia	*J. procera,*	48	0	44 (91.7%)	4 (8.3%)
	A. origena	10	7 (70%)	0	3 (30%)
Ragdan	*J. procera*	53	0	53 (100%)	0
	A. origena	29	29 (100%)	0	0
Al Kahla	*J. procera*	120	0	116 (96.7%)	
	Olea spp.	8	8 (100%)	0	0

BR = Burned and resprouted
BNR = Burned and not resprouted
PBR = Partially burned and resprouted

Table III: Seedlings and saplings of tree species/ha inside the burned areas

Forest	*J. procera*	*Olea* spp.	*A.origena*
Al Hilia	0	0	243
Ragdan	0	0	312
Al Kahla	0	112	189

Table IV: Effect of fire on soil texture and organic matter

Forest status	Soil Depth (cm)	Sand %	Silt %	Clay %	O.M.(g kg^{-1})
Al Hilia forest					
Burned	1-10	55.92 ^{a}	31.60 ^{a}	12.48 ^{a}	3.71 ^{a}
	10-20	50.52 ^{a}	39.20 ^{a}	13.28 ^{a}	5.6 ^{b}
	20-30	59.12 ^{a}	25.20 ^{a}	15.68 ^{a}	2.03 ^{ad}
Unburned	1-10	57.32 ^{a}	26.00 ^{a}	16.68 ^{a}	9.5 ^{c}
	10-20	54.32 ^{a}	31.33 ^{a}	14.34 ^{a}	6.6 ^{b}
	20-30	51.65 ^{a}	35.33 ^{a}	13.01 ^{a}	1.79 ^{d}
Ragdan forest					
Burned	1-10	38.32 ^{a}	45.33 $^{b\,a}$	16.34 ^{a}	2.2 ^{a}
	10-20	29.12 ^{a}	52.66 $^{b\,a}$	18.21 ^{a}	1.6 ^{a}
	20-30	37.8 ^{a}	46.00 ^{ba}	16.20 ^{a}	2.3 ^{b}
Unburned	1-10	39.56 ^{a}	42.00 ^{b}	18.34 ^{a}	6.3 ^{c}
	10-20	27.65 ^{a}	54.66 $^{b\,a}$	17.68 ^{a}	3.3 ^{b}
	20-30	34.32 ^{a}	45.00 $^{b\,a}$	20.68 ^{a}	2.1 ^{a}
Al Kahla forest					
Burned	1-10	35.57 $^{b\,a}$	38.25 ^{c}	16.34 ^{a}	5.4 ^{a}
	10-20	26.94 ^{b}	53.75 $^{b\,a}$	18.21 ^{a}	5.84 ^{b}
	20-30	33.32 $^{b\,a}$	46.00 $^{b\,a\,c}$	16.20 ^{a}	3.53 ^{c}
Unburned	1-10	34.05 $^{b\,a}$	42.33 $^{b\,c}$	18.34 ^{a}	8.41 ^{d}
	10-20	34.05 $^{b\,a}$	46.33 $^{b\,a\,c}$	17.68 ^{a}	5.39 ^{b}
	20-30	31.38 $^{b\,a}$	43.66 $^{b\,c}$	20.68 ^{a}	4.60 ^{c}

Means followed by the same letter in a column in a forest are not significantly different at P = 0.05

Table V: Effect of fire on soil pH and EC

Site	Soil depth (cm)	pH	EC (dsm^{-1})
Al Kahla forest			
Burned	1-10	8.46 ^{a}	1.10 ^{ab}
	10-20	7.06 ^{b}	1.55 ^{c}
	20-30	7.16 ^{b}	0.44 ^{b}
Unburned	1-10	7.34 ^{b}	2.13 ^{d}
	10-20	7.15 ^{b}	0.57 ^{b}
	20-30	7.06 ^{b}	0.63 ^{b}
Ragdan forest			
Burned	1-10	8.50 a	0.76 ^{a}
	10-20	7.30 b	0.74 ^{a}
	20-30	7.22 b	0.50 ^{a}
Unburned	1-10	7.10 b	1.43 ^{b}
	10-20	7.24 b	0.73 ^{a}
	20-30	7.50 b	1.43 ^{b}
Al Hilia forest			
Burned	1-10	8.46 ^{a}	1.01 ^{a}
	10-20	7.06 ^{b}	1.55 ^{a}
	20-30	7.16 ^{b}	0.44 ^{b}
Unburned	1-10	7.34 ^{b}	3.13 ^{c}
	10-20	7.15 ^{b}	0.57 ^{b}
	20-30	7.06 ^{b}	0.63 ^{b}

Table VI: Effect of fire on major and micronutrients

Site	Soil depth (cm)	Major			Micro			
				mg kg^{-1}				
		Pb	Ni	Co	Mo	N	P	K
Al Hilia Forest								
Burned	1-10	0.54 ^{a}	0.50^{a}	0.63^{a}	0.21^{a}	27.66 ^{a}	29.80 ^{a}	96.00 ^{a}
	10-20	0.10 ^{b}	0.21^{b}	0.01^{b}	0.18$^{b\,a\,c}$	20.40 ^{b}	3.60 ^{b}	53.60 ^{b}
	20-30	0.10^{b}	0.12 ^{b}	0.00 ^{c}	0.19 $^{b\,a}$	21.20 ^{b}	1.77 ^{b}	27.60 ^{c}
Unburned	1-10	0.23 ^{b}	0.44 ^{a}	0.03 ^{b}	0.15 $^{b\,c}$	34.50 ^{c}	12.67 ^{c}	63.60 ^{d}
	10-20	0.10 ^{b}	0.12 ^{b}	0.06 ^{c}	0.14 ^{c}	22.33 ^{b}	4.72 ^{b}	22.00 ^{c}
	20-30	0.06 ^{b}	0.21 a	0.01^{b}	0.14 ^{c}	17.66 ^{d}	1.23 ^{b}	22.67 ^{c}
Ragdan forest								
Burned	1-10	0.63$^{b\,a\,c}$	0.36 ^{a}	0.14 ^{a}	0.07 ^{b}	34.0 ^{a}	11.49 ^{a}	202.33 ^{a}
	10-20	0.20 $^{b\,c}$	0.22$^{b\,a}$	0.01^{b}	0.09 $^{a\,b}$	28.33 ^{b}	2.47^{b}	54.00^{b}
	20-30	0.15 ^{c}	0.13 $^{b\,a}$	0.00^{b}	0.09 $^{a\,b}$	22.67 ^{b}	1.19 ^{b}	43.33^{b}
Unburned	1-10	0.71 $^{b\,a}$	0.30$^{b\,a}$	0.12 $^{b\,a}$	0.08 $^{b\,a}$	45 ^{c}	5.58 ^{c}	137.67^{a}
	10-20	0.24$^{b\,c}$	0.25 $^{b\,a}$	0.01^{b}	0.09 $^{b\,a}$	40.33^{c}	1.51 ^{a}	64.00^{b}
	20-30	0.13 ^{c}	0.23 $^{b\,a}$	0.00 ^{b}	0.09 ^{a}	20.67 ^{b}	1.07 ^{a}	35.33 ^{c}
Al Kahla forest								
Burned	1-10	0.31$^{b\,a\,c}$	0.36 $^{b\,a}$	0.15^{a}	0.09 $^{b\,a}$	35.88 ^{a}	5.32 ^{a}	188.75 ^{a}
	10-20	0.12$^{d\,c}$	0.41$^{b\,a}$	0.05 ^{b}	0.09 $^{b\,a}$	26.25 ^{b}	1.77 ^{c}	76.75 ^{b}
	20-30	0.08 ^{d}	0.46 $^{b\,a}$	0.02 ^{b}	0.09 $^{b\,a}$	25.00 ^{b}	1.08 ^{c}	53.00 ^{c}
Unburned	1-10	0.41$^{b\,a}$	0.21^{b}	0.15 ^{a}	0.08 ^{b}	70.00 ^{c}	3.87 ^{b}	140.00 ^{d}
	10-20	0.23 $^{b\,d\,c}$	0.24 ^{b}	0.10 $^{b\,a}$	0.09$^{b\,a}$	32.33 ^{a}	1.88 ^{c}	67.33 ^{b}
	20-30	0.12 $^{d\,c}$	0.33 $^{b\,a}$	0.07 $^{b\,a}$	0.09 $^{b\,a}$	40.25 ^{b}	1.39 ^{c}	48.00 ^{c}

Means followed by the same letter in column in a forest are not significantly different at P = 0.05

DISCUSSION

Very few studies have investigated factors that affect tropical dry forests (Sukumar *et al*., 2005). Climate change, animals and fire are some factors that affected vegetation dynamics in these ecosystems (Silori & Mishra, 2001). The main cause of forest fires in Al Baha region was the fire, which was carelessly lit by summer campers. It has been estimated that about 1-2 million campers visit Aseer and Al Baha regions (south-west Saudi Arabia) in summer time (June-September). A forest fire could be useful or destructive to the forest, while the tree species vary in their responses to forest fires (Hare 1965). Prescribed fire may play an important role in sustainable management of forests subjected to wildfires (Matthias *et al*., 2009). On the other hand, Brian and Kastendick (2009) found evidence that prescribed fire further increased disturbance of the forest ecosystem since shrubs and early successional tree species became abundant. In the current study, *A. origena* benefited from fire, as was indicated by the substantial increase of regeneration and the fact that considerable number of *A. origena* plants resprouted after fire. Hein *et al*. (2010) mentioned that in mixed forests the probability is low for succession after fire. In hard seeded legumes, such as *Acacia* spp., heat from fire may break the hard seed coat and allow water absorption by the seeds and hence dormancy is broken (Sabiiti & Wein, 1987; Mbalo & Witkowski, 1997). This was confirmed earlier by Seth and Kaul (1978), who mentioned that fire partially removed the seed coat of *Tectona grandis*. Sprouting was thought to be controlled by growth hormones (auxins) produced in tips of stems and the neighboring young leaves. Auxins prevent dormant buds to grow into new shoots (Schier *et al*., 1985). As such, removal of stem tips and young leaves by fire, for instance, may allow dormant buds to develop into new shoots. Fire appeared to improve the regeneration potential of *A. origena* by increasing light intensity on the forest floor by increasing canopy cover, and reducing competition from more fire-sensitive saplings and seedlings in the understory such as those of *J. procera* (Barnes & Van Lear, 1998; Adams & Rieske, 2001). It seems that the presence of *A. origena* in fire-prone ecosystem, as the case in the present study, facilitated its adaptation to fire in various ways including thickening of bark, ability to resprout and dispersing of seeds. Hare (1965), mentioned that some trees have thick insulating bark, which protected them from the scorching heat of surface fires. In contrast, *J. procera*, in the present study, was very sensitive to forest fire since it failed to regenerate or only poorly recovered in the burnt soils. *Olea* spp. were also more or less negatively sensitive to fire in terms of regeneration and recovery after forest fire. Species diversity was considerably affected by forest fires, although this effect was dependent on the severity of fire (Kodandapani *et al*., 2008).

Fire had no effect on soil texture in the studied locations. Soil pH increased significantly after fire in all areas. Several studies have reported increase in soil pH after fire (Bauhus *et al*., 1993; Creighton & Santelices, 2003; Ekinci, 2006). Giacomo (2005) mentioned that soil pH in non-calcareous soils increases after fire because of the release of the alkaline cations (Ca, Mg, K, Na) bound to the organic matter. Also fire decreased the EC significantly in the burned sites. Significant reductions in soil organic matter were recorded in all sites in the burned sites. The effect of fire on organic matter comprises volatilization, charring or oxidation (Giovannini *et al*., 1988). Considerable burning of organic matter occurs at 200-460°C (Giovannini *et al*., 1988). Fire causes burning and/or total removal of organic matter (Simard *et al*., 2001). Black carbon is usually produced at 250-500°C from the partial combustion of wood material (Baldock & Smernik, 2002). Neff *et al*. (2005) reported that one year after wildfire, burned soils contained between 1071 and 1420 g/m² less carbon than unburned soils in Alaska.

Generally, a significant reduction in total N occurred after fire especially at 1-10 cm soil depth in all forests under investigation, which is in agreement with Neff *et al*. (2005). Forest floor layers are a major reservoir of soil N and their removal during forest fires can cause significant reductions in it (Driscoll *et al*., 1999). This might be attributed to lixiviation of bases from the mineralization of the litter. Ivanauskas *et al*. (2003) reported that soon after the fire, there was a significant increase in the nutrient levels in the soil, an increase in soil pH and a decrease in the aluminum toxicity. Significant increase in P might be attributed to the fact that burning converts some of the organic pool of soil P to orthophosphate (Cade-Menun *et al*., 2000). Therefore, fires enrich available P (Serrasolsas & Khanna, 1995). Also K was higher after fire than in unburned sites. This is in agreement with Adams and Boyle (1980) who reported increase in K among other elements after fire. As for micronutrients, Mo, Co, Ni and Pb varied in their response to fire and no definitive pattern was evident as reported by Giacomo (2005).

The present study revealed that fire encouraged fire-tolerant tree species and discouraged fire-sensitive species as reported by Ivanauskas *et al*. (2003). *A. origena* has relatively thicker and fissured barks and this might explain its resistance to fire relative to *J. procera,* which have relatively thin barks. Uhl and Kauffman (1990), reported that tree response to fire greatly depends on bark thickness for instance, *Aparisthmium cordatum*, *Miconia ligustroides* and *Jacaranda copaia* had extremely light barks that can't survive temperatures higher than 60ºC (Uhl & Kauffman, 1990). In contrast *A. guianensis* has a thicker bark and was almost unaffected by the fire. The fact that fire had benefited regeneration and dominance of *A. origena* in contrast to *J. procera*, might be an indicator to a possible succession in the studied forests. Christopher *et al.* (2010) mentioned that prescribed fire is a tool for restoring fire-adapted ecosystems. Since *J. procera* is an important tree in the region for touristic, cultural and heritage reasons, an immediate intervention concerning encouragement of regeneration of the species is highly recommended including artificial regeneration to maintain its sustainability.

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