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Post-fire dynamics of the forest formations in the mounts of Tlemcen (Western of Algeria): Case of the Forest of Zarifet

Hasnaoui Okkacha[1,2], Bessaid Farah[1], Bourouaha Mohamed[1,2], Babali Brahim[2], Aouadj Sid Ahmed[2] & Khatir Hadj[3]

[1]Department of Biology, Faculty of Sciences, University of Saida-Dr. Moulay Tahar, Saida, Algeria
[2]Laboratory of Ecology and Management of Natural Ecosystems, Department of Ecology and environment, Faculty of Nature and Life Sciences and Earth and Universe Sciences, Abou Bakr Belkaid University of Tlemcen, Algeria
[3]Private scientific consultant and a head of Reprodbiotech and Stem Cells, Montréal, Canada
*Corresponding author, email: okkacha.hasnaoui@univ-Saida.dz; okhasnaoui2001@yahoo.fr

ABSTRACT A study on the post-fire dynamics of plant species in the Zarifet forest (National Park of Tlemcen, north-western Algeria) was conducted after a violent fire that destroyed more than 200 hectares in the month of October 2016. Floristic records were done at a control site and the burned area during the phenological period, which extends from 2017 to 2019. The analysis of the floristic succession indicated a continuum of population dynamics over the three years after the fire. The results showed that the number of species found in the burnt sites reached 52 species (39%) after 8 months from the initial fire and 121 of them (91%) at three years afterward. The natural regrowth of the vegetation in the Tlemcen Mountains is typical of the "tiger bush". The competitivity between the different species has been highlighted in the present study. The most competitive species in the post-fire occupation of the soil are stump-rejecting species and geophytes one, such as *Quercus ilex, Chamaerops humilis, Calicotome intermedia, Asparagus acutifolius, Ulex boivinii, Drimia maritima, Cistus* sp., *Stipa tenacissima* and *Ampelodesmos mauritanicus*. The analysis of the frequency indices (F.I.) seem to be in favor of an expanding tendency of these taxa.

KEY WORDS Biological Rise; Dynamics; Fire; Floristic diversity; Frequency Index; Zarifet-Forest.

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INTRODUCTION

Most ecosystems nowadays are subject to various types of disturbance. A disturbed ecosystem is defined as one which is exposed to an altering event (or events) in time and in space. Many habitats are exposed to natural or human induced disturbances. In this context, Lavorel et al. (2006) reported that wildfire is a major threat to Mediterranean forests, affecting both animal and plant biodiversity and its management as well. Le Houerou (1980) has estimated that more than 200,000 hectares of forest are burnt each year throughout the Mediterranean basin. For Valez (1990) this figure is worst and the number of hectares affected is between 700,000 and 100,000.

This destabilizing phenomenon is amplified by the climatic disturbances of recent decades with a reduction in rainfall accumulation and an increase in the dry period (Hasnaoui, 2008). In Algeria, a southern Mediterranean country, vegetation formations are affected by the destructive impacts of human activities such as fires, tree-cutting, clearing, overgrazing and urban expansion (Hasnaoui & Bouazza, 2015). The work of Benderradji et al. (2004) shows that an average of 30,000 ha are destroyed by fire each year and that the surfaces burnt per site depend on whether it is in the North-East (37 ha), the North-Centre (18 ha) or the North-West (51 ha) of the country. This difference may be explained by the climate conditions, the substratum, geomorphology of the ground, the nature of the vegetation formations and the rapidity of the fighters in intervening.

Studies carried out in the western part of Algeria have revealed a regressive dynamic of the vegetative cover in the last few years (Bouhraoua, 2003; Hasnaoui, 2008; Letreuch-Belarouci, 2009; Hachemi et al., 2014; Bouhraoua et al., 2014; Medjati et al, 2014; Belgherbi & Benabdelli, 2015; Guenaia et al., 2019; Aouadj et al., 2020; Dahmani et al., 2021). This dynamic regression necessitates the restoration and the rehabilitation of these degraded ecosystems.

The Zarifet forest is one of the important forests of the Tlemcen Mountains (North-Western Algeria). It is part of the national park of the Tlemcen Wilaya. It represents a good model to study the resiliency processes and the temporal and/or spatial dynamics of plant species after a disturbance. In fact, it is subject to a combination of disturbed habitats and may contain a varying type and level of disturbance (i.e., fire, grazing, etc.).

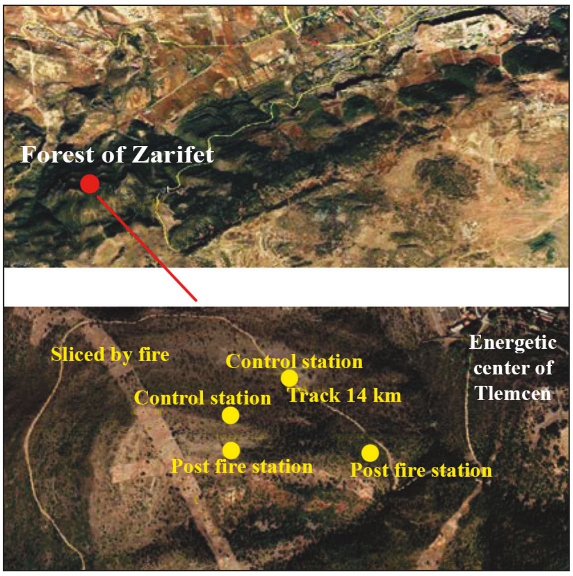

Figure 1. Location study area.

The aim of this present study, carried out on the forest species of Zarifet (Tlemcen Mountains), is to highlight the influence of the temporal gradient on the floristic evolution of burnt sites.

The fire that occurred in Zarifet happened in 2016 and has destroyed more than 200 hectares, changing the face of the landscape. This disastrous phenomenon was followed by a vegetation response that led to a succession based on the nature of the taxa burnt, the soil, the topography, the violence of the fire and the climate.

The objective was to quantify the damage caused by this fire, assessing the post-fire biological recovery and to identify the competitive regenerative strategies of the main taxa. Understanding the post-fire dynamics of ecosystems may helps to optimize the rehabilitation strategies of the Tlemcen National Park.

MATERIAL AND METHODS

The study area

The state forest of Zarifet is part of the biogeographically sub-sector of the Tellian Atlas "O3". It is mainly composed of carbonate land of Jurassic age and, particularly, the substratum belongs to the carbonate series of the Upper Jurassic (Benest, 1985). The forest is characterized by variable plant formations, exposed to a climatic-anthropic synergy often leading to disturbances in biological cycles. According to Boudy (1950), the Zarifet forest is divided into 4 cantons covering 926 ha and occupying a very uneven relief whose altitude varies between 1000 and 1217 m. Administratively, the Zarifet forest is bordered to the north by the commune of Mansourah, to the south by the ridges of Béni Bahdel, to the east by Terny and to the west by the communes of Zelboun and Béni Master. It is part of the Tlemcen forestry district (Fig. 1).

The region of Tlemcen belongs to the Mediterranean climate, which is characterized by high levels of sunshine and dry summers (maximum temperatures range between 25 and 40 °C) and mild, wet winters (average minimum temperatures 5 °C). The region is characterized by inter-monthly and inter-annual rainfall irregularities (Bouazza & Benabadji, 2010). According to Bouazza et al. (2020) recent data from the Zarifet region (between 1975 and 2016) recorded an average rainfall of 484 mm, an average maximum temperature of 32.5 °C in August and a minimum temperature of 3.2 °C in January, with a length of the dry period ranging from 6 to 7 months per year. Located not far from the towns of Hafir, Beni Mester and Terni, the forest formations are exposed to climatic-anthropic constraints (low rainfall, high temperature and anthropic pressures - cutting, fires and overgrazing). As such, part of the Zarifet forest caught fire in October 2016. The geographical data of the burnt sites are 1° 38'13'' West longitude and 34°83'55'' North latitude.

Methodology

In order to know the dynamics of the plant communities, a three-year monitoring was carried out, based on the following aspects:

1. Evaluation of the damage caused by fire according to a severity scale.
2. Biological recovery using the frequency index (F.I.). Inventory of species that appear after the fire with an analysis of the landscape using the abundance-dominance scale of Braun Blanquet (1954). The frequency of a species reflects the adaptation of the plants to the environment where it occurs; it is formulated as follows (Gaussen, 1963):

$$F = (n/N) \times 100$$

With n = number of surveys containing the species studied; N = number of surveys carried out.

Du Rietz (1931) divided the frequencies into 5 classes, each corresponding to a frequency index (F.I.) (Table 1).

Frequency	Frequency Index (F.I.)
F <20%	I
20%≤F≥ 40%	II
40%≤F≥60%	III
60%≤F≥80%	IV
80%≤F=100%	V

Table 1. Frequency Classes according to Du Rietz (1931).

3. Floristic evolution of the regrowth: This approach is based on the regenerative dynamics of the taxa by inventorying the species in the sites selected on the one hand, and by using frequency indices (F.I.) on the other. The sampling made it possible to carry out 90 phytosociological surveys in the sites selected in this study. The interest of this subjective type of sampling (Guinochet, 1973) is to be able to choose surveys according to homogeneity criteria. The first criterion of homogeneity of the surface explored corresponds to a geomorphological homogeneity represented by the topography and the nature of the soil. The second criterion corresponds to the homogeneity of the vegetation. This homogeneity is dependent on the scale and therefore on the area selected. The area recognized to ensure visual homogeneity and to represent the total floristic procession of the plant formation is 100 m^2. This corresponds to the minimum area of cork oak forests and tree maquis in Algeria (Zeraïa, 1982). We carried out 45 floristic surveys in the control site and 45 in the site burned during the follow-up period. The sampling take apart in the spring of 2017-2018 and 2019 (March to June). It is the period when most plant species reach their optimum development (flowering fruiting), which facilitates the identification of taxa. The nomenclature adopted follows that of Quézel & Santa (1962-1963); Dobignard & Chatelain (2010); Le Floc'h, Boulos & Vela (2010).

RESULTS

According to our field survey and just after the fire, we assessed the intensity of the fire by determining the damage caused. Different criteria concerning the vegetation or the soil were taken into consideration. The concept of fire severity, which measures the degree of impact of fire on the combustion of biomass and soil organic matter, corresponds to a fire severity scale (Alexander, 1982; Brown & Davis, 1973; Feller, 1996; Alexandrian, 1997). In our case the fire destroyed 208 ha of forest, including 35 ha of oak, 67 ha of green oak and 106 ha of scrub (C.F.T, 2016). In the field, we found damaged tree trunks, burnt crowns, burnt undergrowth stems and exposed mineral soil. These observations classify the intensity of the fire as category 4 on a scale of 6 (Lampin et al., 2003; Amandier, 2004).

Year / Species	Diversity of the control site (2017-2019)			Diversity of the burned site (2017-2019)			
	Family	Frequency %	I. F	Frequency (8 Months)	I.F	Frequency (After 3 years)	I.F
Allium roseum L.	Alliaceae	13.33	I	00	--	13.33	I
Narcissus cantabricus DC.	Amaryllidaceae	6.66	I	00	--	00	
Pistacia lentiscus L.	Anacardiaceae	22.22	II	22.22	II	22.22	II
Arisarum vulgare M. et W.	Araceae	6.66	I	00	--	10	I
Biarum bovei Engler		13.33	I	00	--	13.33	I
Chamaerops humilis L.	Arecaceae	44.44	III	26.66	II	53.33	III
Aristolochia baetica L.	Aristolochiaceae	8.88	I	00	--	6.66	I
Asparagus acutifolius L.	Asparagaceae	20	II	13.33	I	23.33	II
Asparagus albus L.		26.66	II	13.33	I	26.66	II
Asphodelus microcarpus Salzm. and Viv.	Asphodelaceae	31.11	II	20	II	33.33	II
Borago officinalis L.	Boraginaceae	13.33	I	00	--	10	I
Cerinthe major L.		6.66	I	00	--	00	--
Cynoglossum cheirifolium L.		13.33	I	00	--	00	--
Echium vulgare L.		22.22	II	00		23.33	II
Lonicera implexa L.	Capripholiaceae	33.33	II	00		13.33	I
Viburnum tinus subsp. *tinus* L.		28.88	II	66.66	I	20	II
Paronychia argentea Lam.	Caryophylaceae	22.22	II	00		00	
Silene vulgaris (Moench) Garcke		6.66	I	00		6.6	I
Silene latifolia Poiret		13.33	II	00		13.33	I
Stellaria media (L.) Vill.		8.88	I	00		10	I
Cistus clusii Dunal.	Cistaceae	33.33	II	00		23.33	II
Cistus villosus L.		26.66	II	13.33	I	20	II
Cistus ladaniferus L.		24.44	I	20	II	26.66	II
Cistus salvifolius L.		22.22	II	13.33	I	26.66	II
Fumana thymifolia (L.) Webb		13.33	I	6.66	I	13.33	I
Halimium umbellatum (L.)		17.77	I	00		13.33	I
Helianthemum cinereum (Cav.) Pers.		15.55	I	6.66	I	20	II
Anacyclus pyrethrum (L.) Link	Asteraceae	15.55	I	00		16.66	I
Atractylis cancellata L.		8.88	I	00		16.66	I
Bellis sylvestris L.		6.66	I	00		10	I
Micropus bombycinus Lag.		8.88	I	00		00	
Calendula arvensis L.		11.11	I	00		00	
Centaurea pullata L.		6.66	I	00		6.66	I
Carlina gummifera (L.) Less.		13.33	I	6.66	I	16.66	I
Catananche caerulea L.		26.66	II	13.33	I	30	II
Cichorium intybus L.		22.22	II	13.33	I	26.66	II
Cirsium echinatum (Desf.) DC.		22.22	II	20	II	33.33	III
Dittrichia viscosa (L.) Greuter		31.11	II	20	II	43.33	III
Echinops spinosus L.		6.66	I	00	I	10	II
Filago fuscescens Pomel		20	I	00		13.33	I
Inula viscosa L.		22.22	I	13.33	I	26.66	II

Pallenis spinosa (L.) Cass.		8.88	I	00		10	I
Phagnalon saxatile (L.) Cass		11.11	I	6.66	I	10	I
*Galactites tomentosus*Moench		6.66	I	00		6.66	I
Leotodon tuberosus L.		11.11	I	00		13.33	I
Scolymus hispanicus L.		13.33	I	00		6.66	I
Senecio vulgaris L.		13.33	I	00		10	I
Sonchus asper (L.) Hill		8.88	I	00		10	I
Taraxacum officinale L.		6.66	I	00		13.33	I
Urospermum picroides L.		17.77	I	00		6.66	I
Convolvulus althaeoides L.	Convulvulaceae	6.66	I	00		00	
Sedum sediforme (Jacq.) Pau	Crassulaceae	13.33	I	00		6.66	I
Sedum album L.		8.88	I	00		6.66	I
Umbilicus rupestris (Salisb.) Dandy		13.33	I	00		6.66	I
Biscutella didyma L.	Brassicaceae	6.66	I	00		6.66	I
Lobularia maritima (L.) Desv.		17.77	I	6.66	I	13.33	I
Raphanus raphanistrum L.		13.33	I	00		6.66	I
Sinapis alba L.		6.66	I	00		10	I
Sinapis arvensis L.		11.11	I	00		6.66	I
Centaurea scabiosa L.	Dipsacaceae	15.55	I	00		6.66	I
Arbutus unedo L.	Ericaceae	28.88	II	13.33	I	26.66	II
Erica arborea L.		24.44	II	6.66	I	23.33	II
Cocciferous quercus L.	Fagaceae	13.33	I	6.66	I	20	II
Quercus ilex L.		43.33	III	20	II	46.66	III
Quercus suber L.		46.662	III	20	II	43.33	III
Aegilops geniculata Roth	Poaceae	6.66	I	00		10	I
Aegilops triuncialis L.			I	00		13.33	I
*Ampelodesma mauritanica (*Poiret) Dur. et Sch.		22.22	II	13.33	I	46.66	III
Stipa tenacissima L.		17.77	I	13.33	I	43.33	III
Bromus matritensis L.		8.88	I	00		13.33	I
Bromus rubens L.		13.33	I	00		6.66	I
Avena sativa L.		6.66	I	00		6.66	I
Avena sterilis L.		11.11	I	00		10	I
*Brachypodium sylvaticum (*Huds.) P.B		8.88	I	00		13.33	I
Briza maxima L.		13.33	I	00		13.33	I
Festuca coerulescens Desf.		17.77	I	00		10	I
Hordeum murinum L.		6.66	I	00		00	
Lagurus ovatus L.		8.88	I	00		00	
Drimia maritima (L.) Sream	Hyacinthaceae	22.22	II	13.33		23.33	II
Muscari comosum (L.) Mill.		8.88	I	6.66		10	I
Muscari neglectum Guss. ex Ten.		11.11	I	00		10	I
Ornithogalum umbellatum L.		8.88	I	00		10	I
Scilla autumnalis L.		13.33	I	00		13.33	I
Romulea bulbocodium (L.) Seb. et Maur.		17.77	I	6.66		13.33	I
Ajuga chamaephitis Schreb.	Lamiaceae	6.66	I	00		10	I
Ajuga iva (L.) Schreb. subsp. *iva*		13.33	I	00		6.66	I

Ballota hirsuta Bentham		22.22	II	6.66		23.33	II
Calamintha nepeta (L.) Savi		13.33	I	00		6.66	I
Lamium aplexicaule L.		17.77	I	00		10	I
Lavandula stoechas L.		13.33	I	6.66		10	I
Marrubium vulgare L.		15.55	I	6.66		13.33	II
Phlomis crinita Cav.		22.22	II	6.66	I	23.33	II
Rosmarinus officinalis L.		13.33	I	6.66	I	16.66	I
Verbenaca sage L.		6.66	I	00		6.66	I
Teucrium fruticans L.		11.11	I	6.66	I	13.66	I
Thymus ciliatus L.		13.33	I	00		6.66	I
Anthyllis would violate L.	Fabaceae	8.88	I	00		6.66	I
Calicotome intermedia (Salt) C. Presl		26.66	II	13.33	I	30	II
Cytisus triflorus L'Herit		20	I	10	I	23.33	I
Medicago polymorpha L.		6.66	I	00		6.66	I
Ulex boivinii Webb		22.22	II	13.33	I	23.33	I
Trifolium stellatum L.		8.88	I	6.66		6.66	I
Trifolium tomentosum L.		8.88	I	00		10	I
Vicia onobrychioides L.		13.33	I	00		6.66	I
Fritillaria oranensis Raf.	Liliaceae	6.66	I	00		00	I
Gagea durieui Parl. ex Trab.		11.11	I	6.66	I	13.66	I
Gagea granatelli (Parl.) Parl.		15.55	I	6.66	I	13.33	I
Tulipa sylvestris L.		13.33	I	00		6.66	I
Anagallis arvensis L.	Primulaceae	6.66	I	00		00	--
Jasminum fruticans L.	Oleaceae	17.77	I	10	I	20	I
Phillyrea angustifolia L.		20	I	6.66		20	
Adonis aestivalis L.	Ranunculaceae	6.66	I	00		6.66	I
Anemone cf. *coronaria* L.		8.88	I	00		10	I
Anemone coronaria L.		13.33	I	00		6.66	I
Clematis flammula L.		15.55	I	00		00	-
Ranunculus arvensis L.		11.11	I	00		10	I
Ranunculus spicatus Desf.		13.33	I	00		10	I
Reseda alba L.	Resedaceae	8.88	I	6.66		13.33	I
Reseda phyteuma L.		6.66	I	00		6.66	I
Crataegus oxyacantha L.	Rosaceae	24.44	II	20		26.66	I
Rosa canina L.		28.88	II	13.33		26.66	II
Rubus ulmifolius Schott		20	I	6.66		16.66	I
Sanguisorba minor Scop.		13.33	I	6.66		10	I
Scrophularia laevigata Vahl	Scrophiliaceae	6.66	I	6.66		13.33	I
Scrophularia canina L.		8.88	I			10	I
Verbascum blattaria L.		15.55	I	6.66		16.66	I
Smilax aspera L.	Smilacaceae	13.33	I	6.66		16.66	I
Daphne gnidium L.	Thymelaeaceae	22.22	II	13.33		26.66	II
Bupleurum rigidum L.	Apiaceae	6.66	I	00		6.66	I
Eryngium tricuspidatum L.		8.88	I	00		10	I
Ferula communis L.		8.88	I	6.66		16.66	I
Thapsia garganica L.		13.33	I	13.33		20	I

Table 2. Summarizes the species recorded between 2017 and 2019 in these two different sites (Zarifet forest, Tlemcen Mountains, North-Western Algeria).

The changes in the vegetation and the environment are studied simultaneously at several areas, which theoretically represent different dynamic stages of the plant community studied (Arnaud; 1984). To establish a comparative study, we compiled lists of species on the control site and the burnt one.

One hundred and thirty three species (133) belonging to 35 botanical families were recorded in the control site, which indicates the richness of the study area. Therophytes such as Astreraceae, Poaceae, Apiaceae, Renonculaceae Brassicaceae, Scrophyllariaceae, represent more than 53% of the overall richness of the Zarifet forest. The phanerophytes and the chamaephytes groups (e.g. Anacardiaceae, Fagaceae; Oleaceae; Arecaceae, Asparagaceae, Cistaceae, Ericaceae, Thymelaeaceae, Rosaceae and Lamiaceae) represent about 25.5%; while tuberous plants such as Hyacinthaceae, Iiridaceae, Liliaceae, Asphodeliaceae, Aliaceae and Liliaceae (geophytes species) occupy more than 12% of this diversify wealth. The rest of the plant cover is occupied by hemicryptophytes such as *Pallenis maritima*, *Paronychia argentea*, *Phlomis crinita*, *Ranunculus arvensis*, *Scolymus hispanicus*, *Ajuga iva*, *Centaurea pullata*, *Eryngium* sp. (Table 3).

The evolution of the floristic content of the surveys illustrates the dynamic gradient across the stages selected (control site; biological recovery after 8 months and 3 years later). The floristic richness corresponds to the number of species found in each of the sites studied during the phenological period (spring of 2017, 2018 and 2019) and constitutes the station richness. The maximum of species were found at the control site, with 133 species as mentioned above. In the burnt site, 52 species were recorded eight months after the fire incident, which represents about 39% of the total

Biological types	**Species**
Phanerophytes	*Olea europaea, Quercus suber, Quercus coccifera, Arbutus unedo, Erica arborea, Quercus ilex, Rosa canina, Crataegus oxyacantha.*
Nanophanerophytes	*Pistacia lentiscus, Jasminum fruticans.*
Chamaephytes	*Chamaerops humilis, Cistus salvifolius, Fumana thymifolia, Helianthemum* sp., *Ballota hirsuta, Daphne gnidium, Ampelodesmos mauritanicus, Stipa tenacissima, Ulex boivinii, Calicotome intermedia, Lobularia maritima, Marrubium vulgare, Rosmarinus officinalis, Salvia verbenaca, Teucrium polium, Asparagus acutifolius, Thymus ciliatus.*
Hemicryptophytes	*Ajuga iva, Centaurea pullata, Eryngium* sp., *Pallenis maritima, Paronychia argentea, Phlomis mane, Ranunculus arvensis, Scolymus hispanicus.*
Geophytes	*Asphodelus microcarpus, Iris xyphium, Drimia maritima, Ornithogalum umbellatum, Narcissus* sp., *Muscari comosum, Scylla autumnalis, Allium roseum.*
Therophytes	*Anacyclus clavatus, Anagallis arvensis, Avena sativa, Bellis annua, Bromus rubens, Bromus* sp., *Calendula arvensis, Daucus carota, Eruca vesicaria, Hordeum maritimum, Plantago lagopus, Raphanus raphanistrum, Reseda alba, Silene colorata, Sinapis arvensis, Trifolium stellatum.*

Table 3. The principal biological types at the study area.

floristic richness recorded and 121 species (91%) were recorded three years after the fire initiation. Nevertheless, a disappearance of 12 species (representing 9% from the plant cover) was noted after 3 years from the initial fire. The physiological activities of the plants seem to be accelerated because to the favorable stationary conditions (openness of the environment, richness of the soil in organic matter and germination of species stimulated by the fire).

Analysis of FIs in the various reports during the survey showed a variable dynamic between species, which depends on the adaptive strategy of taxa. We observed that species such as *Chamaerops humilis*, *Stipa tenacissima*, *Ampelodesmos mauritanicus*, *Ulex boivinii*, *Quercus ilex*, *Drimia maritima* occupy more space with a F.I. from II to III after 3 years from the fire began. It should be mentioned, that, even if some species keep the same F.I. value, their rate (percentage) increased, which can be considered as a competitive species following fire damage. This strategy directs the existing ecosystem towards a change in the landscape (Figs. 2, 3).

As reported by Trabaud (1993), the maximum expression of species can also be observed in the second year after the passage of fire. The decrease in floristic wealth during the regeneration has been reported for most Mediterranean ecosystems regardless of the disturbance factor (fire, grazing) (Tatoni & Roche, 1994; Noy-Meir, 1995; Debussche et al., 1996; Saidi et al., 2016). However, we have seen a dynamic regrowth in favor of chamaephytes and geophysicists, with an expense of therophytes during the follow-up period.

The study highlighted three dynamics of functioning:

1) the first is based on regenerations either by rejection of strains and/or new shoots as is the case of the main phanerophytes and chamaephytes such as *Quercus suber*, *Pistacia lentiscus*, *Quercus ilex*, *Rosa canina*, *Daphne gnidium*, *Chamaerops humilis*, etc);

2) The second is based on tuberous plants, as is the case of *Drimia maritima*, *Allium roseum*, *Muscari comosum*, *Romulea bulbocodium*.

3) The third is related to the seed flows associated with dissemination vectors (anemochoria; zoochoria and anthropochorie). This is the case of therophytes famillies such as *Avena sativa*, *Bellis annua*, *Bromus rubens*, *Bromus* sp., *Calendula arvensis*, *Daucus carota*, *Eruca vesicaria*, *Hordeum maritimum*, *Plantago lagopus.*

CONCLUSIONS

Plants regrowth in the Zarifet forest have a "tiger bush" aspect and were characterized by the dominance of species with an adaptive strategy based on resilience and physiological responses of taxa. In our case there are such species as *Quercus ilex, Pistacia lentiscus, Chamaerops humilis*, *Cistus* sp., *Calicotome intermedia*, *Ampelodesmos mauritanicus*, *Daphne gnidium*, *Crataegus oxyacantha*,

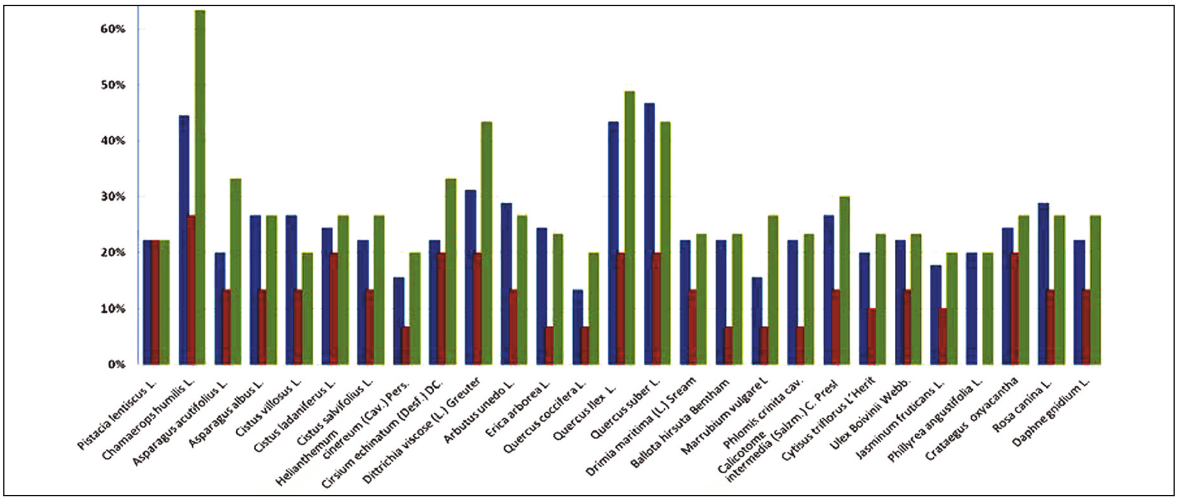

Figure 2. Floristic evolution of the regeneration.

Figure 3. On the left, the Zarifet forest after the fire in October 2016. On the left, the same place in March 2019.

Rosa canina and bulbs such as *Drimia maritima*, *Romulea bulbocodium.* The functional response of these species to trauma is very significant after 8 months of the start of the fire and tend to occupy more space; which represented 39% of the total species recorded. Three years after the fire, we found the species in a more matured state with a recovery of the floristic diversity in which 91% of the species have been regenerated.

The invasion of the environment by pioneer species is mainly due to the regeneration power of strain rejection and the stock of dormant seeds in the soil, whose germination is rapidly triggered in the spring following the trauma.

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REFERENCES

Alexander M.E., 1982. Calculating and interpreting forest fire intensities. Canadian Journal of Botany - Revue Canadienne de Botanique 60: 349–357.

Alexandrian D., 1997. Etat des méthodes de caractérisation des incendies dans “Convention INRA-DERF 61.21.14/97”, pp. 19–29.

Amandier L., 2004. Le comportement du Chêne-liège après l’incendie consequences sur la regeneration naturelle des suberaies. Actes du coloque- VIV Expo 2004: Le chêne liège face au feu, pp. 1–18.

Aouadj S.A., Nasrallah Y. & Hasnaoui O., 2020. Ecological characterization and evaluation of the floristic potential of the forest of Doui Thabet (Saida Western Algeria) in the context of the restoration. Ecology, Environment and Conservation, 26: 266–278.

Arnaud M.Th., 1984. Première approche de la dynamique des groupements à châtaignier (*Castanea sativa* Mill.) en région méditerranéenne: proposition d’une méthode d’étude. Écologie méditerranéenne, 10*:* 105–118.

Belgherbi B. & Benabdeli K., 2015. Quelle stratégie pour la préservation de *Quercus Suber* (Chêne liège) en Algérie occidentale Télliènne? Geo-Eco-Trop, 39: 87–100.

Benderradji M.H, Alatou D. & Arfa A., 2004. Bilan des incendies de forêts dans le Nord-Est algérien: Cas de Skikda, Annaba et El Tarf période 1990–2000. Forêt méditerranéenne, 25: 211–217.

Benest M., 1985. Évolution de la plate-forme de l’Ouest algérien et du Nord-Est marocain au cours du Jurassique supérieur et au début du Crétacé: stratigraphie, milieux de dépôt et dynamique sédimentaire. Travaux et Documents des Laboratoires de Géologie de Lyon, 95: 369–581.

Bouazza M. & Benabadji N., 2010. Changements climatiques et menaces sur la vegetation en Algérie occidentale. Changements climatiques et biodiversité. Vuibert-APAS. Paris, pp. 101–110.

Bouazza N., Cherifi K., Babali B. & Bouazza M., 2020. Bibliographical note on the syntoxonomy of the vegetation of Tlemcen, Hafir, Moutas and its reserve (North western Algeria). Bangladesh Journal of Plant Taxonomy, 27: 345–358. https://doi.org/10.3329/bjpt.v27i2.50673

Boudy P., 1950. Guides du forestier en Afrique du Nord. La maison rustique, Paris, XI, 505 pp.

Bouhraoua R.T., 2003. Situation sanitaire de quelques forêts de chêne liège de l'ouest Algérien. Etude particulière des problèmes posés par insectes. Thèse de Doctorat d'etat, Département Forestiere, Faculté de Sciences Université, Tlemcen, Algérie, 267 pp.

Bouhraoua R.T., Piazzetta R. & Berriah A., 2014. Les reboisements en chêne-liège en Algérie, entre contraintes écologiques et exigences techniques. Journées techniques du liège. Forêt méditerranéenne, 35: 171–176.

Braun-Blanquet J., 1932. Plant sociology, the study of plant communities. New York, McGraw-Hill Book Company, 439 pp.

Brown A.A. & Davis K.P., 1973. Combustion of forest fuels. In: "Forest Fire: Control and Use", McGraw-Hill Book Company, New York, pp. 155–182.

Dahmani R., Merzouk A. & Aouadj S.A., 2021. Incidences of anthropogenic pressure on the degradation of the scrub of the western Algerian region (Tlemcen, case of Djebel Felloucene): qualitative and quantitative aspects. Biodiversity Journal, 12: 755–760 https://doi.org/10.31396/Biodiv.Jour.2021.12.3.755.760

Debussche M., Escarré J., Lepart J., Houssard C. & Lavorel S., 1996. Changes in Mediterranean plant succession: Old fields revisited. Journal of Vegetation Science, 7: 519–526.

Dobignard A. & Chatelain C., 2010. Index synonymique et bibliographique de la flore d'Afrique du Nord. In: Base de données des plantes à fleurs d'Afrique. Conservatoire et jardin Botaniques de la ville de Genève/South African National Biodiversity Institute.

Du Rietz G.E., 1931. Life forms of terrestrial flowering plants. Acta Phytogeographica Suecica, 3: 1–95.

Feller M.C., 1996. The influence of fire severity, not fire intensity, on understory vegetation biomass in British Columbia, 13th Conference on Fire and Meteorology, Lorne, Australia, 27–31/10/1996.

Guenaia A., Hasnaoui O. & Bekkouche A., 2019. Study of the floristic diversity of *Acacia tortilis* population-in Bechar Region (southwestern Algeria). South Asian Journal of Experimental Biology, 9: 133–141. https://doi.org/10.38150/sajeb.9(4).p133-141

Gaussen H., 1963. Carte bioclimatique de la zone méditerranéenne, Notice explicative, UNESCO, Paris, 21: 1–60.

Guinochet M., 1973. Phytosociologie et systématique. In: Taxonomy and Ecology. The Systematics Association, 5: 121–140.

Hachemi N., Hasnaoui O., Benmehdi I., Medjati N. & Bouazza M., 2012. Contribution à l'étude de la thérophytisation des matorrals des versants sud des monts de Tlemcen (Algérie occidentale). Universidad de Alicante. Departamento de Ecología, pp. 158–180.

Hasnaoui O., 2008. Contribution à l'étude des Chamaeropaies dans la région de Tlemcen, Aspects botanique et cartographiques. Thèse de Doctorat en Sciences, Université Tlemcen, Algérie, 210 pp.

Hasnaoui O. & Bouazza M., 2015. Indicateurs de dégradation des bio-ressources naturelles de l'Algérie occidentale: cas de la steppe de la wilaya de Saida. Algerian Journal of Arid Environment, 5: 63–75.

Lampin-Cabaret C., Jappiot M., Alibert N. & Manlay R., 2003. Une échelle d'intensité pour le phénomène incendie de forêts. SIRNAT- JPRN, Orléans, pp. 1–10.

Le Floc'h E, Boulos L. & Véla E., 2010. Catalogue synonymique commenté de la Flore de Tunisie. République Tunisienne, Ministère de l'Environnement et du Développement durable, Banque Nationale de Gènes, 504 pp.

Lavorel S., Flannigan M.D., Lambin E.F. & Scholes M.C., 2006. Vulnerability of land systems to fire: interactions among humans, climate, the atmosphere, and ecosystems. Mitigation and Adaptation Strategies for Global Change, 12: 33–53.

Letreuch-Belarouci A., 2009. Caractérisations structurale des subéraies du parc national de Tlemcen, régénération naturelle et gestion durable. Thèse de Doctorat en Sciences, Université Tlemcen, Algérie, 224 pp. + Annexes.

Le Houerou H.N., 1980. L'impact de l'homme et ses animaux sur la forêt méditerranéenne. Forêt Méditerranéenne, 2: 31–44.

Médjati N., Hasnaoui O. & Bouazza M., 2013. Functional response post-fire of *Chamaerops humilis* L. (Arecaceae). Agricultural Journal, 8: 32–36.

Noy-Meir I., 1995. Interative effects of fire and grazing on structure and diversity of mediterranean grasslands. Journal of Vegetation Science. 6: 701–710.

Quézel P. & Santa S., 1963. Nouvelle flore de l'Algérie et des régions désertiques méridionales. Paris, CNRS, 2 tomes, 1170 pp.

Saidi B., Latrèche A., Mehdadi Z., Hakemi Z. & Bouker A., 2016. Post-disturbance (post-fire or post-overgrazing) dynamics of plant communities in the Tessala mounts, western Algeria. Ecologia mediterranea, 42: 41–49.

Tatoni Th. & Roche Ph., 1994. Comparison of old-field and forest revegetation dynamics in Provence. Journal of Vegetation Science, 5: 295–302.

Trabaud L., 1993. Reconstitution après incendie de communautés ligneuses des Albères (Pyrénées Orientales françaises). Vie & Milieu, 43: 43–51.

Valez R., 1990. Les incendies de forêts dans la région méditerranéenne: panorama régional. Unasylva, Bulletin de la FAO, 162: 3–9.

Zeraïa L., 1982. Le chêne liège: phytosociologie, édaphologie, régénération et productivité. INRF, 159 pp.