Are wildland fires threatening the Mediterranean flora and vegetation?

L. Trabaud
Centre d'Ecologie Fonctionnelle et Evolutive, CNRS, UPR 9056, 1919 route de Mende, 34293 Montpellier, France
Email: trabaud@cefe.cnrs-mop.fr

Abstract

Fire is an ancient and universal ecological force which has shaped most of plant communities and landscapes of the Mediterranean basin. Associated with climate and topography, fire has contributed to create, but not always predominantly, the types of vegetation growing around the Mediterranean Sea. In any study dealing with plant dynamics after fire, qualitative and quantitative aspects should be considered. Immediately after fire (first months to first year) floristic richness is lower than in unburned sites; then during the second to fifth years it becomes higher. This is due to a progressive recovery of communities and also an invasion of many annuals attempting to occupy the burned open sites. But towards the fifth year after fire the floristic richness reaches a composition similar to the prefire one. In the same way, as communities get older, their structure becomes more and more complex, with numerous strata depending on the original complexity.

Present ecological systems of the Mediterranean area are the result of an ancient historical influence during which species have used mechanisms to overcome fire effects but also to resist to other disturbances. To-day, fire is really not a factor of change of Mediterranean ecosystems. Present species have developed several survival traits the best adapted to survive the disturbances. Management strategies that ignore the fundamental instability of ecological systems are totally unsound and ultimately lead to surprises. Depending on fire regime and frequency the Mediterranean vegetation has reach an equilibrium. In any elaboration of management plan of natural areas, fire must be considered as an integral part of fire-fighting planification.

1 Introduction

Fire is an ancient and universal force which has shaped most of the types of vegetation and landscapes of the Mediterranean basin. Associated with climate and topography, fire has contributed to create, but not always predominantly, the plant communities growing around the Mediterranean Sea. However, in absence of fire, the different landscapes have been also modelled by the human action which has been strongly exerted for thousands of years.

It is difficult to know with certainty how old is the fire influence on the Earth; however, there is no doubt that its occurrence predated human advent. Fire could occur as soon as a terrestrial vegetation grew on soil (Harris,[1] Komarek[2]). Lightning is a natural cause, with also volcanic eruptions which could light wilfires. Also during geologic times, other phenomena as meteorites could set fires (Wolbach et al.[3]; Jones & Chaloner[4]).

Before humans, fire was a natural component appearing more or less regularly in the natural cycle of ecosystem dynamics. Its passage allowed the rejuvenation of some stands and created a mosaic of plant communities. Time intervals between successive wildfires could be very long. This natural equilibrium was disrupted when Humans arrived on the scene substituting an artificial situation and upsetting the previous order. Humans have used and misused fire; which, associated with tree felling, grazing by domestic animals and an extensive but agressive agriculture (destruction and uprooting of competitive plants), contributed to shape the landscapes existing nowadays in the Mediterranean basin countries. Due to its old influence, fire sometimes controls the age, structure and species composition of many plant communities. Fire acts with several frequencies and intensities, depending on vegetation and climate conditions. Thus, these different factors react the ones on the others: vegetation affects fire regimes which in turn create vegetational communities.

For a long time fire was considered as a factor of vegetation degradation. More than fifty years ago, some authors (Braun-Blanquet,[5] Kuhnholtz-Lordat,[6] Kornas[7]) considered the subject , but they did not precisely tackle it. Generally they described degraded stages by comparing burned sites; but they did not exactly analyse the vegetation succession process in the course of time after fire. Some of them quoted names of species the most frequently « observed » in burned sites (*Quercus coccifera*, *Arbutus unedo*, *Cistus* spp., *Pinus* spp.). Their descriptions compared stages a priori considered as belonging to the regressive succession of Mediterranean vegetation: from *Quercus ilex* forest, through garrigues of *Q. coccifera*, to end at *Brachypodium retusum* swards. However, these authors did not study in a detailed manner the impact of fire on standing communities nor the actual fate occurring after the disturbance. It was only in the early 70s that the subject was newly and really objectively studied.

In any study dealing with plant dynamics, qualitative and quantitative aspects should be analysed; the former concerns the floristic changes brought about during the course of time, the latter the structural changes which occur due to the growth of plants. Both aspects will be considered.

2 Flora and vegetation responses to fire in southern France

Vegetation dynamics was mainly studied in the calcareous region of Bas-Languedoc (Trabaud;[8,9] Trabaud & Lepart[10]). Forty seven plots were permanently surveyed during 10 to 12 years. They were located in 8 types of communities epresentative of the most dominant ones in the area: woodlands, shrublands (garrigues) and swards. The diachronic method was used to follow the modifications of flora and structure through time. On each site a permanent transect line (20 m long) and a plot of 100 m^2 were examined regularly in spring.

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After fire, vegetation turns rapidly back to its previous state. The first species to appear and re-establish were those constituting the communities 10 years after fire. The return towards a state identical to that existing prior to fire was rapid. One year after fire 70% of the studied plots had more than 75% of the species present 10 to 12 years later. Two years after fire, this percentage exceeded 80%; and in five years reached 100% (Fig. 1).

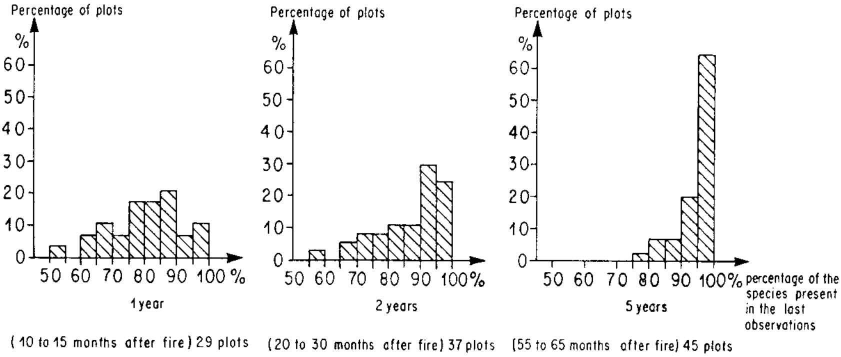

Figure 1: Three measurements of the relative importance of species present in the terminal communities in Bas-Languedoc.

For all the communities ,the changes of floristic composition followed an identical model. In the first months after fire, there were few species. Then due to annuals which tended to occupy the burned sites, floristic richness increased reaching maximum values between the first and third years. But because of the competition from community species reestablishing these invaders disappeared. Beyond the fifth year, richness tended to stabilize.

As progressively communities got older, their structure became more and more complex, with more and more numerous strata corresponding to the pre-fire ones (Fig. 2).In forest stands, vegetation grew up from lower strata (0-50 cm) to reach higher strata (2-4 m) in 10 years. Vegetation physiognomy tended to be similar to that of unburned communities (Trabaud[11]).

Forests of *Pinus halepensis* (which pay a heavy tribute to wildfires), were more particularly studied (Trabaud et al.[12,13]) on a synchronic way. Whatever the type of forest (two kinds of understorey were recognized characterizing two floristically different communities), the increase of understorey phytomass went through three phases: the first phase lasting for two years showed a rapid increase; during the second phase, when only the shrubs grew, the phytomass slowly increased; then a third phase without any growth, when shrubs had reached their adult size. Thirty years after fire, the understorey phytomass ranged between 9 and 12 t ha^{-1}. Pine density increased up to a maximum reached during the fifth and fifteenth year, then decreased, because of mortality due to inter- and intra-specific competition. Distribution of young pines was uniform on all the studied sites. This result apparently was due to a superimposition of seed rains coming from various sources. This type of regeneration and dispersion was

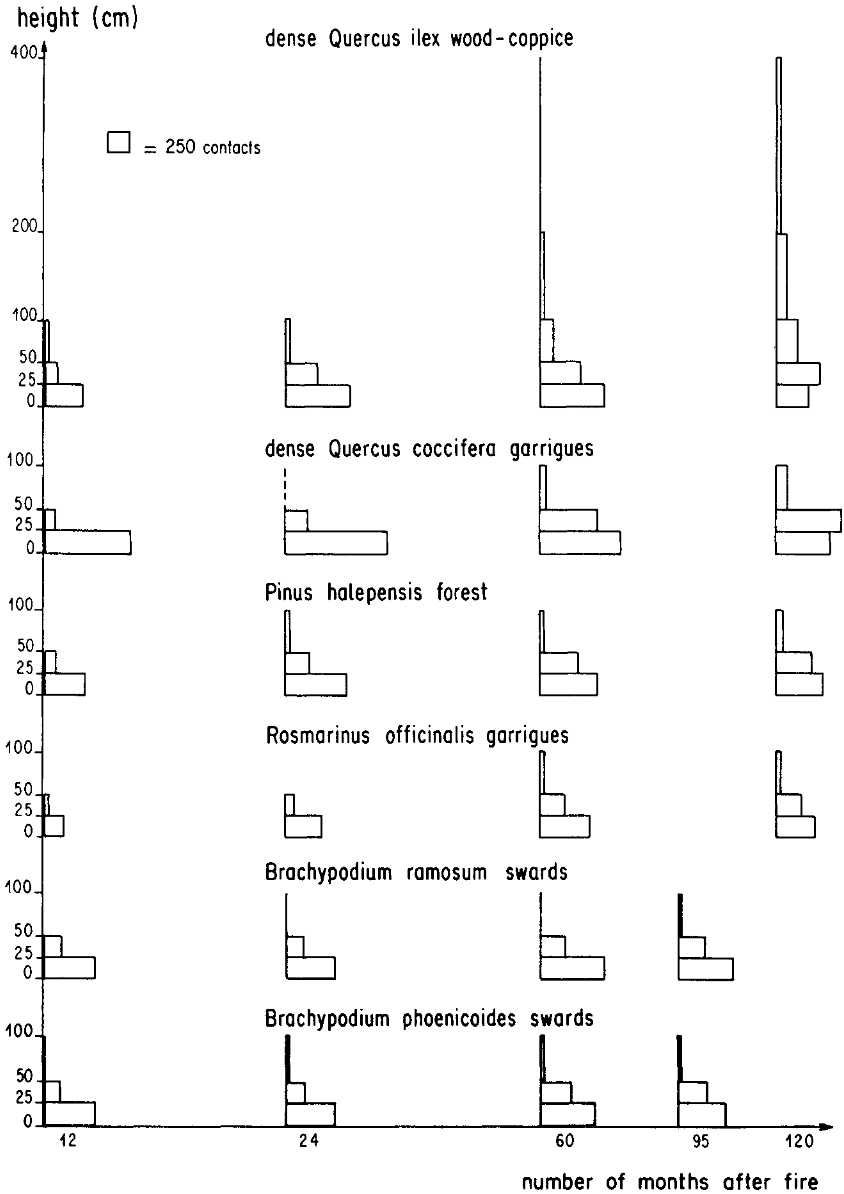

Figure 2: Reconstitution through time of the structure in burned communities of Bas-Languedoc (from Trabaud 1983).

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confirmed in Provence (Abbas et al.[14], Barbero et al.[15]) and in Catalonia (Papio[16]). The same model of floristic and architectural recovery was also stated in the Baleares Islands (Morey & Trabaud[17]).

Among the shrubby communities studied, the *Quercus coccifera* garrigue presented a great resilience. In spite of frequent burnings its floristic composition remained practically unchanged (Trabaud,[18,19,20] Trabaud & Lepart[21]) and its ability to reconstitute was strong (Malanson & Trabaud[22]). Phytomass recovery was rapid: on an average 1 t ha^{-1} yr^{-1} . The architecture (horizontal and vertical structure, density and distribution of stems) was rapidly reconstructed.

In the siliceous mountains of Albères (eastern end of Pyrénées), 9 permanent plots (diachronic method) were set up in a *Quercus ilex* forest and an *Erica arborea* maquis.There too (Trabaud[23]) species reappeared immediately after fire. During the first two years, annual plants were extremely abundant. Perennial species which established were those pre-existing to disturbance. Floristic richness was higher in the burned sites than in unburned ones. The structure tended to reconstruct similar to the previous one (Fig. 3). In the same area and Aspres Prodon et al.[24]studying the recovery of 6 types of burned communities including woodlands of *Quercus ilex* and *Q. suber*, maquis and swards, observed the same conclusions.

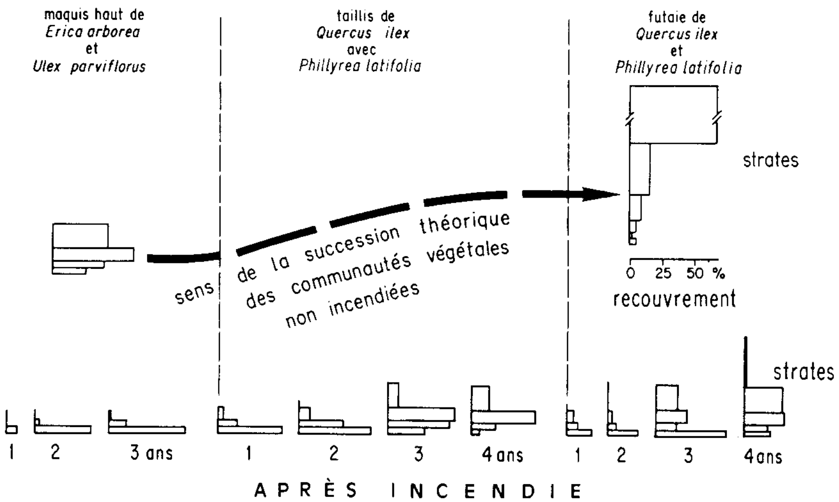

Figure 3: An example of structure of vegetation in burned and unburned communities in Albères (from Trabaud 1993).

3 Discussion on plant resistance in mediterranean ecosystems

In these last twenty years noticeable researches have been carried out in the Mediterranean basin countries (Greece, Israel, Italy, Portugal, Spain), and published in several conference proceedings and books: Bourdeau et al.,[25] Terradas,[26] Trabaud,[27] Goldammer & Jenkins,28 Trabaud & Prodon.29. When comparisons are made between results, all the authors agree to the same conclusions: the species existing before fire did re-establish and reconstitute the communities; most of them come by vegetative regeneration from resprouting organs. They appear very soon, practically all during the five first years following fire. There was no renewal of communities, in the sense of a community replacing another one, but simply « autosuccession » in the sense of Hanes[30] a burned community re-establish identical to itself.

Living biota and ecological systems can disappear because of misappreciation of their functioning and dynamics. This statement has two important implications. First, the concept of fundamental instability as a natural characteristic of some ecosystems conflicts with some of the most appreciated paradigms. While classical concepts of succession are more and more criticized, there is still widespread belief that ecosystem development will lead to a stable system maintained by homeostatic mechanisms in a general climate without disturbances. Developmental pathways that lead to inevitable dramaticaly unstable systems is an antithesis contrary to normal concepts.

Secondly, management strategies that ignore the fundamental instability of certain ecological systems and the high resilience of biota are totally unsound and ultimately lead to surprises. The present high proportion of wildfires, as the larger burned areas can be due (and they absolutely are) to the utmost fire-fighting and victory of this battle that induces a greater fuel accumulation and then increases wildfire occurrence.This continuous buildup of fuel leads to « unnatural » disastrous ineluctable conflagrations.

In the global process of ecosystem dynamics, each participating species has different needs. Certain plants grow only in the shade of forest stands; by contrast other ones thrive only on rocky sites or full-lit swards; it is the same for animals. Fire is not always negative. If fire must not be allowed to destroy a forest, to preserve a garrigue and its plants, fire can be let to pursue its run because belonging species are resistant to fire and because rapidly the shrubland will return to its previous state and then will regain all the fauna and flora components living in it.

According to all the results of the researches carried out during the three last decades, regeneration of ecological systems after fire in the Mediterranean region is not modified: they tend (more or less rapidly according to their former complexity) to a structure and floristic composition similar to the previous ones.

The majority of plants reappearing after fire comes from survival organs (rhizomes, lignotubers, bulbs, seeds, etc.) already present in the soil before the passage of the flame; or scattered (seeds) immediately after fire by plants remaining alive in unburned patches or located in the neighborough. There is no plant alien to the previous stands able to invade and persist in the areas repetitively burned for millenia. All the plants which regenerate by vegetative means give sprouts during the very early first months whatever the season following a fire.

This general tendency is less perceptible in the soil system where the effects of wildfires are different. The differences can be explained by the fact that soils

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are unactive systems, reacting slowly to weather conditions, and depending upon the vegetal cover for their protection and nutrient cycling during the vegetation recovery phases. Owing to their great mobility, animals possess high capacities to recolonize burned sites; however, as for their food as for their habitat they are dependent on the vegetal cover dynamics.

The biotic communities pertaining to the ecological systems and landscapes of the Mediterranean basin present a high tolerance to fire. How this tolerance can be called: resilience, stability, persistance, elasticity, inertia? These terms are numerous and well-characteristic of the recovery possibility of organisms and populations. Fire repeated during millenia has destroyed or eliminated the less resistant individuals and species; thus reducing a potential competition; only presently (but for a long time) persist the species and populations able to resist and adapted to repeated passages of disturbances, fire being one of them. The Mediterranean flora does not seem threatened by fires if those are not too frequent.The stability of ecological systems of the Mediterranean basin would be characterized by a high resilience associated with a strong inertia and a noteworthy resistance. They are « dynamically robust » systems.

4 Conclusion

Old land uses of reclamation, agriculture, fallow and grazing strongly have modified the original landscape. Generally, at first, trees were cut, then burned and plant stumps and roots up-rooted to establish crops; then fields were abandoned followed or not by grazing, pastoral fires succeeded to agricultural burnings, lands were again abandoned and then again cleared, then abandoned in a cycle re-occurring several times according to the rhythm of socio-economic needs. These uses led to a multiplicity of plant communities able to survive the disturbances and have shaped in a mosaic pattern the landscapes of today.

Are fire cycles existing? A knowledge of fire frequencies is extremely important to understand the relative stability of ecosystmes. When fires occur too frequently changes can appear in plant or animal populations, some species can disappear, new others can appear; the same can also occur when fire intervals are too long. If after fire, dynamics are characterized by a relative stability and an adaptation of species to withstand disturbances, then the repetition of fire cycle leads to a permanence of species and communities.

The present ecological systems of the Mediterranean area are the result of an ancient historical influence during which species have acquired mechanisms to overcome fire effects, but also to resist to other environmental constraints (disturbances and stresses) such as bad climatic periods (drought and coldness). Both fire and human activities, as well as climate, have favored an ecological and genetical differenciation which ended into the constitution of the present fauna, flora and vegetation. Because of these past vicissitudes, today fire is really not a factor of change of Mediterranean ecological systems. Each species has developed different and several characteristic survival traits the best adapted for its needs allowing it to survive the disturbances and to perpetuate itself as to maintain the communities in which it is living.

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