Selective Shrub Management to Preserve Mediterranean Forests and Reduce the Risk of Fire: The Case of Mainland Portugal

Mauro A.M. Raposo [1,2] , **Carlos J. Pinto Gomes** [1,2] and **Leonel J.R. Nunes** [3,*]

[1] Departamento da Paisagem, Ambiente e Ordenamento, Universidade de Évora, 7000-671 Évora, Portugal; mraposo@uevora.pt (M.A.M.R.); cpgomes@uevora.pt (C.J.P.G.)

[2] MED—Mediterranean Institute for Agriculture, Environment and Development, Pólo da Mitra, Universidade de Évora, 7006-554 Évora, Portugal

[3] ProMetheus—Unidade de Investigação em Materiais, Energia e Ambiente para a Sustentabilidade, Escola Superior Agrária, Instituto Politécnico de Viana do Castelo, Rua da Escola Industrial e Comercial de Nun'Alvares, 4900-347 Viana do Castelo, Portugal

* Correspondence: leonelnunes@esa.ipvc.pt; Tel.: +351-258-909-740

Abstract: The recurrent rural fires that occur annually in Portugal have reached great proportions due to a lack of effective landscape management. Attempts to solve this problem led to the legal imposition to cut back the vegetation in the fuel management areas, which has had a negative effect on biodiversity. National legislation protects three native plant species (*Quercus suber*, *Q. rotundifolia* and *Ilex aquifolium*). European legislation, through the Habitats Directive, also identifies some plant species that require strict protection, although it leaves out several endemic and rare plants. In this work we aim to differentiate the types of shrub plant material and their pyrophilic behavior, since the physical and chemical characteristics of vegetation can enhance or inhibit the progression of fire. Thus, based on phytosociological science, specifically at the class level, the dynamics of potential climatophilous vegetation in Portugal are presented and the classes that should be prioritized for control are identified. Based on ecology, it was possible to identify morphological patterns of vegetation. In short, the genera targeted for control under the National Forest Fire Protection Plan belong to the furthest states from the mature potential of a forest, generally consisting of heliophile shrubs and typically growing in degraded soils. The shrub species to be valued belong to dynamic states closer to the mature potential, consisting mainly of broad-leaved shrubs and those growing in better-preserved soils.

Keywords: phytosociology; forest; rural fires; vegetation management; heliophile shrubs

1. Introduction

Of the five existing macro-climates in the world, the Mediterranean is the one with the greatest diversity of shrub plants [1,2]. This fact, associated with the high number of endemic species, led the WWF (Word Wide Fund for Nature) to consider the Mediterranean Basin one of the great biodiversity hotspots worldwide [3]. However, several threats are destroying this genetic heritage, such as the fires that occurred in recent decades in mainland Portugal [4–7]. In addition to occurring more frequently, there has also been an increase in the burnt area, accumulating to hundreds of thousands of hectares. One of the worst years was 2017, with a total of 442,418 hectares burned and 64 human lives lost in the region of Pedrogão Grande [8,9].

Faced with this situation, political agents have been forced to invest in better planning and adopt fire prevention strategies [10,11]. According to the new European Union strategy for forests and the forest sector, there is a need for the reinforcement of protection measures relating to issues such as

habitat fragmentation, the spread of invasive alien species, climate change, water scarcity, fires, storms and pests [12]. However, although Portugal has specific legislation to address these joint concerns, such as Decree-Law no. 17/2009, which establishes structural measures and actions related to the prevention and protection of forests against fires, it is necessary to address this issue in a more objective and uncomplicated way [13]. Other studies have been conducted on the management of vegetation cover; however, it is necessary to deepen our knowledge about the constitution of shrub plant material and the main differences between its components [14,15].

Forests in Portugal occupy about 3.2 million hectares, corresponding to 35.4% of the national territory [16]. However, only 2% of this area is under the tutelage of the Portuguese State, the rest being managed by private or local entities, which hinders the correct management and implementation of new measures [17]. In addition to the difficulty in implementing these measures, it is necessary to determine the type of vegetation that must be controlled [18]. Decree-Law no. 17/2009 establishes the mandatory removal of vegetation within national territory (10 m from the road network and 50 m from buildings). This requirement has resulted in the radical cutting of all vegetation within these bounds, with the exception of holly (Decree-Law 423/89), cork oak and holm oak (Decree-Law No. 169/2001, as amended by Decree-Law 155/2004), since these species are protected by national legislation. The protection of the cork oak and holm oak is related to the lack of natural regeneration that was verified in Portugal, especially to the South of the Tagus river, which prevents the renewal of the stands. Equally protected is holly, due to the Christmas tradition of cutting the branches of this species for decoration.
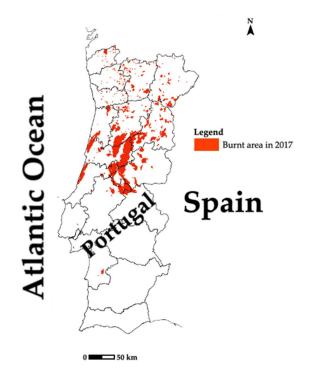
Although the dispersion of flames within wildfires is influenced by a variety of factors, such as temperature, humidity and orography, among many others, in this study we intend to focus on what really burns, namely, the plant material. From the point of view of landscape management to reduce the risk of fire, it is easier to control vegetation than to control climatic factors. The morphology of the flora—the dimensions, shapes, textures and chemical characteristics—can promote or inhibit the advance of the flames. In general, resinous plants are more prone to catch fire than oaks, due to the high amount of flammable terpenes present in the resin [19], as are plants with high levels of essential oils [20]. Accordingly, the National Forest Authority has published a manual with a dozen species to be avoided in the fuel management ranges [21]. Despite this initial contribution, it is necessary to have a better understanding of the high diversity of existing flora, its framing in terms of the dynamics of vegetation cover and its pyrophilic characteristics.

From a conservation point of view, fuel management bands should not be "dead" areas, so it is necessary to distinguish the different types of vegetation [22]. In this sense, there is an intention to improve existing knowledge about plant communities in Portugal, in order to create strategies that are more appropriate to increase resilience and at the same time to reduce the risk of fire. In addition, the Habitats Directive has outlined a set of species of community interest to conserve, due to the high patrimonial value or because they play important functions in ecosystems that must be safeguarded.

The objective of this work is to contribute, based on field knowledge, to reduce the risk of fire in rural Mediterranean landscapes, through a rational management of vegetation cover. Of all the macro-climates in the world, the Mediterranean is the one with the greatest diversity of shrub species. However, some of them are rare and endemic to this region, so it is essential to develop selective management methods that promote their conservation. Although the element of fire is naturally part of southern Europe's landscapes, this is a factor that inhibits the development of progressive dynamics, namely the mature state of forests, promoting soil degradation and the emergence of primary scrub in ecological succession. Thus, the knowledge produced in this study will directly contribute to the local agents that operationalize the management in the field, as well as to the sensitization and valorization of the floristic heritage. In fact, the selective management of the vegetation cover must even integrate the regional political intrusions, through the National Plan for the Defense of the Forest Against Fires.

2. Materials and Methods

This study focuses on the vegetation of the Mediterranean basin, giving special emphasis to the Portuguese territory due to the serious fire problems that have occurred there in recent decades. The data collection, based on the areas burned in 2017 in the central area of Portugal (Figure 1), was carried out during the spring of 2018.

Figure 1. Location of burnt areas in mainland Portugal in 2017 (Source: GNR—Guarda Nacional Republicana, Forestry Technical Offices, Landsat and Copernicus, obtained through the website of ICNF—Institute for Nature Conservation, available at www.icnf.pt).

The following works were used to identify the flora—*Flora Ibérica* [23], *Flora de Portugal* [24], *Nova Flora de Portugal* [25–28], *Flora of Western Andalusia* [29] and *Flora of Italy* [30–33]. For the interpretation of the vegetation cover, we used a phytosociological methodology, according to the standards of the Zurich-Montepellier Sigmatist school, proposed by Braun-Blanquet (1979) [34], Géhu and Rivas-Martínez (1981) [35] and Rivas-Martínez (2005) [36]. The definition and description of the vegetation series followed the taxonomic and syntaxonomic nomenclature presented by Rivas-Martínez et al. (2011) [37] and is complemented by the most recent publication by Costa et al. (2012) [38].

The center of mainland Portugal is influenced by the pluviestational Mediterranean bioclimate, under an ombrotype of subhumid to humid, a thermomediterranean to supramediterranean zone and semihyperoceanic to euoceanic continentality [39]. In terms of vegetation, climatophilous position dominates the *Quercus suber* oak trees of the association *Asparago aphilly-Quercetum suberis* and *Q. pyrenaica* of the association *Arisaro simorrhini-Quercetum pyrenaicae* [22].

The assessment of problems with fuel management areas was based on bibliographic research, consisting of national legislation and documents produced by public entities [40–46]. Based on this information, an analysis was carried out on the indicated measures, with a view to improving the state of conservation through a scientific approach.

3. Vegetation Dynamics

Phytosociology—a science that incorporates the evolutionary and regressive information about a community of vegetation cover until it reaches a mature forest—studies the set of dynamic phases formed by different plants [22]. Usually, after the abandonment of agricultural land and depending on the seed bank available, annual plants appear first (for example, some plants of the genera *Briza*, *Tuberaria*, *Avena*, *Bromus*, *Cynosurus*, *Lagurus* and *Vulpia*). The lack of soil mobilization allows the installation of perennial herbaceous plants (such as many of the plants of the genera *Dactylis*, *Stipa*, *Celtica*, *Brachypodium*, *Avenulla*, *Agrostis* and *Hyparrhenia*). A few years after the abandonment, the first shrubs appear, which are almost always of a heliophilic character (for example, plants of the genera *Thymus*, *Helichrysum*, *Cistus*, *Calluna*, *Erica*, *Lavandula*, *Rosmarinus*, *Pterosparthum*, *Halimium*, *Stauracanthus* and *Ulex*). With the conservation of the soil and in more climatically favorable zones, the most demanding heliophilous shrubs at the substrate level appear (such as plants of the genus *Retama*, *Cytisus*, *Adenocarpus* and *Genista*). With dynamic evolution and after a few years of soil conservation, the first pre-forest shrubs appear, normally producers of small fruits which serve as food for a large number of birds (for example, plants of the genera *Arbutus*, *Myrtus*, *Phillyrea*, *Pistacia*, *Rhamnus*, *Viburnum*, *Crataegus*, *Laurus* and *Ilex*). The most advanced stage of the climatophilic forests of Portugal is normally dominated by trees of the genus *Quercus*, although, due to human action, these formations are very fragmented, consisting of small remnants. Table 1 presents a synthesis of the dynamic evolution of climatophilic vegetation cover in mainland Portugal, and Figure 2 presents the dynamics of climatophilic vegetation in the Mediterranean.

Table 1. Synthesis of the dynamic evolution of climatophilic vegetation cover in mainland Portugal.

Stage	Community	Bioindicator Genera
1	Annual grasslands	*Briza, Tuberaria, Avena, Bromus, Cynosurus, Lagurus, Vulpia*
2	Perennial grasslands	*Dactylis, Stipa, Celtica, Brachypodium, Avenulla, Agrostis, Hyparrhenia*
3	Heathland	*Thymus, Cistus, Calluna, Erica, Lavandula, Rosmarinus, Pterosparthum, Halimium, Stauracanthus, Ulex*
4	Broomland	*Cytisus, Retama, Adenocarpus, Genista*
5	Maquis scrubland	*Arbutus, Myrtus, Phillyrea, Pistacia, Rhamnus, Viburnum, Crataegus, Laurus, Ilex*
6	Forest	*Quercus*

Figure 2. Dynamics of climatophilic vegetation in the Mediterranean: 1—annual grasslands; 2—perennial grasslands; 3—heathland; 4—broomland; 5—maquis scrubland; 6—forest (Author: M. Raposo, 2020).

4. Results and Discussion

4.1. Post-Fire Analysis

During a fire, the vegetation consumed more quickly by the flames corresponds to smaller materials, leaving (according to the intensity of the fire) coarser woody materials (Figure 3). In this study, it was observed that in the burnt areas of autochthonous hardwood forest in central Portugal in October 2017, the leftover woody materials of a smaller dimension were an average of 5 mm thick. All branches with a diameter greater than 5 mm were only scorched and did not burn completely. This result depends on a set of climatic variables and the type of existing vegetation. However, with a view to reducing the spread of fire, human action manages the type of vegetation cover better than climatic conditions.

Figure 3. Vegetation regeneration nine months after a rural fire in Mata da Margaraça (Arganil, Portugal).

This fact helps us to realize that the priority in the control of vegetation can and should be selective, contributing to the reduction of costs/time of management of the vegetation cover. That is, all shrubs of which the well-developed adult form has thin branches, with narrow, long leaves and covered with hair (usually gray-colored bushes and bushes with a fine texture) should be a priority in control actions (Figure 4).

Figure 4. Heliophile shrubs with fine texture and fast combustibility. (**a**) *Calluna vulgaris*; (**b**) *Cytisus scoparius*; and (**c**) *Erica cinerea*.

Smaller shrubs are usually associated with the first stages of evolution of the vegetation cover. These plants often have a set of characteristics in common, specifically related to adaptation to water stress, such as the formation of spines, narrow leaves, having a leathery texture and being covered with hair, and in some cases the production of essential oils. These initial stages of the vegetation cover fall into phytosociological terms in the classes *Cisto-Lavanduletea*, *Rosmarinetea officinalis*, *Calluno-Ulicetea* and *Cytisetea scopario-striati*. On the other hand, larger shrubs have well-developed leaves, are wide and withstand half-shade environments (Figure 5). These characteristics are less prone to the advance of flames.

Figure 5. Pre-forested bushes with broad texture and slower combustibility. (**a**) *Arbutus unedo*; (**b**) *Viburnum tinus*; and (**c**) *Prunus lusitanica*.

4.2. Vegetation Cover Management

The opening of clearings within a forest allows the entry of light and, consequently, the appearance of heliophilous shrubs, thus increasing the risk of fire. Therefore, from an ecological point of view, in order to reduce the prevalence of shrubs with greater flammability, it is necessary to drive the growth of the forest towards a closed canopy. Thus, forest managers should favor pre-forest shrubs (step 5 of Figure 2) and the mature state species (step 6 of Figure 2).

The potential climatophilous vegetation in mainland Portugal is dominated by oak forests. Throughout the main stages of the replacement of these forests, the (pre)forest and heliophile shrubs are differentiated. In short, the climatophilic forest communities to be conserved fall into the *Querco-Fagetea* and *Quercetea ilicis* classes, and on the other hand, the heliophile communities to be controlled mostly belong to the *Cisto-Lavanduletea*, *Rosmarinetea officinalis*, *Calluno-Ulicetea* and *Cytisetea scopario-striati* classes. Thus, Table 2 shows the main shrub species that must be conserved/controlled in the fuel management ranges in mainland Portugal. In addition to this list, all native trees must be conserved, as well as deciduous shrubs.

Table 2. Main native shrub genera to conserve and control in fuel management bands in Portugal.

Genus	Family	Preserve	Control
Adenocarpus	Fabaceae		×
Arbutus	Ericaceae	×	
Asparagus	Asparagaceae	×	
Calluna	Ericaceae		×
Cistus	Cistaceae		×
Clematis	Ranunculaceae	×	
Cytisus	Fabaceae		×
Erica	Ericaceae		×
Genista	Fabaceae		×
Halimium	Cistaceae		×
Helichrysum	Asteraceae		×

Table 2. *Cont.*

Genus	Family	Preserve	Control
Juniperus	Cupressaceae	×	
Ilex	Aquifoliaceae	×	
Laurus	Lauraceae	×	
Lavandula	Lamiaceae		×
Lonicera	Caprifoliaceae	×	
Hedera	Araliaceae	×	
Myrica	Myricaceae	×	
Myrtus	Myrtaceae	×	
Phillyrea	Oleaceae	×	
Pistacia	Anacardiaceae	×	
Prunus	Rosaceae	×	
Pteridium	Dennstaedtiaceae		×
Pterospartum	Fabaceae		×
Retama	Fabaceae		×
Rhamnus	Rhamnaceae	×	
Rhododendron	Ericaceae	×	
Rosmarinus	Lamiaceae		×
Rubus	Rosaceae		×
Ruscus	Asparagaceae	×	
Smilax	Smilacaceae	×	
Stauracanthus	Fabaceae		×
Ulex	Fabaceae		×
Viburnum	Caprifoliaceae	×	

Against this backdrop, the main genera to be controlled belong to Adenocarpus, Calluna, Cistus, Cytisus, Erica, Genista, Halimium, Lavandula, Pteridium, Pterospartum, Retama, Rosmarinus, Rubus, Helichrysum, Stauracanthus and Ulex [47–50]. In addition to controlling the plants referred to in Table 1, it is essential to develop actions to control and eradicate exotic invasive plants. As an example, serious environmental, social and economic problems are caused by Acacia species, such as Acacia dealbata or A. longifolia, Hakea sericea, Ailanthus altissima and Robinia pseudoacacia, among many others [51,52]. Usually, the reduction of the plant material is carried out by human action, through cutting back of bushes. Thus, with this methodology, the operator must have the knowledge to cut only the heliophile bushes and leave all pre-forest and forest bushes. In this way, the technician reduces the necessary work and manages to cover a larger area in less time, although this reduction of time is very dependent on each area of intervention and on the state of evolution of the dynamics of the vegetation cover.

5. Conclusions

Although the control of vegetation in the fuel management areas is mandatory in Portugal according to Decree-Law no. 17/2009, from a conservation and cost management point of view, the control of vegetation must be selective. Despite the national legislation protecting the cork oak, holm oak and holly, it is necessary to value all plants that are characteristic of forest and pre-forest environments, since in the long term, a closed canopy reduces the numbers of heliophile species and, therefore, reduces the risk of fire. Considering this, we sought to study, from the point of view of phytosociological science, the dynamics of vegetation in these areas in order to distinguish target plants for control measures from plants that contribute to the balance and sustainability of the landscape.

It should be noted that the territories targeted by fire are more susceptible to the occurrence of new fires, not only due to greater abandonment of rural spaces, with the consequent increase in the number of heliophilous plants and invasive plants, but also because of the lower resilience of plant communities of greater ecological value, such as forests. This fact is related to soil loss and, consequently, to lower water retention in the short term. In this sense, it will be essential in the future for policy makers to

take this information into account in order to establish valuable ecosystem services, holding those who destroy these natural values responsible. Thus, applying this methodology, regardless of climatic, orographic and anthropogenic factors, it is possible to significantly reduce the materials available for rapid combustion and thus inhibit the rapid advance of flames.

In short, the plants to be conserved within fuel management areas belong to more evolved dynamic states, belonging to the phytosociological classes *Querco-Fagetea sylvaticae* and *Quercetea ilicis*, normally presenting broad leaves. Some of these plants are protected by the previously referenced Decree-Law, however, it is necessary to include the species in annexes II, IV and V of the Habitats Directive (92/43/CEE).

On the other hand, the bushes to be controlled belong to dynamic states farther from the mature stages, affiliated with the classes *Cisto-Lavanduletea*, *Rosmarinetea officinalis*, *Calluno-Ulicetea* and *Cytisetea scopario-striati*. These shrubs preferentially live in situations with high sun exposure and low levels of organic matter, often consisting of narrow leaves and covered with hair. In addition to these, all exotic plants, especially those of an invasive nature, must also be controlled through the respective recommended techniques. It should also be noted that interventions must be carried out from upstream to downstream, avoiding (re)sowing from upstream surfaces.

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