Current status of Prescribed Burning Laws in Italy, Spain, and Portugal: A Comparative Study

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ABSTRACT

Prescribed burning (PB) is a practice that reduces wildfire hazard by burning excessive vegetation under specific topographical and environmental conditions, and with the supervision of qualified personnel. Fire-adapted ecosystems benefit most from PB. Additionally, PB aids with some land management objectives.

In the Mediterranean European region, this practice could represent a great opportunity to lessen the negative impacts caused every year by large wildfires. However, PB is not homogenously applied across Southern Europe. PB is mainly limited by policies that restrict its use. While there is some general information about the current state of laws governing PB in Southern Europe, there is no study that goes into detail about the policies. This study reviews and compares the PB policies of Portugal, Spain, and Italy, three nations where PB is used, by emphasizing key elements.

Only Portugal has a national legislative framework for PB; in Spain and Italy, it is primarily governed on a regional scale. Catalonia, with a comprehensive decree-law, has provided the most stringent rules for PB in Spain. Recent laws in Italy's Campania and Apulia have been approved solely for the use of PB. The remaining Spanish and Italian Regions regulate PB either via legislations or plans for wildfire management, with varying degrees of restriction. The technical directives and objectives for PB operations vary regionally depending on local geographical conditions. Currently, only the Catalan and Portuguese laws outline the necessary training course for PB-qualified staff, whilst in the other regions the identification of the authorized personnel is not clear. The study also discusses the implementation of PB in the agro-pastoral context.

The study identifies which regulatory models aid the implementation of PB the most while addressing the gaps in the legal frameworks for PB in Southern Europe.

Keywords: Prescribed Burning, Policy, Portugal, Spain, Italy.

RESUMO

O fogo controlado (FC) é uma prática que reduz o risco de incêndios florestais reduzindo a quantidade de vegetação (biomassa) sob condições topográficas e ambientais específicas e com a supervisão de pessoal qualificado. Os ecossistemas adaptados ao fogo beneficiam desta utilização do fogo controlado. Além disso, o fogo controlado permite gerir a vegetação ao nível da paisagem.

Na Europa mediterrânica, esta prática pode representar uma oportunidade para diminuir os danos anualmente causados por grandes incêndios florestais. Porém, o uso do fogo controlado não é aplicado de forma homogénea em todo o Mediterrâneo. A sua utilização é limitada principalmente por políticas que restringem o seu uso. Embora existam algumas informações gerais sobre o estado das leis que regem o FC na Europa mediterrânica, não há nenhum estudo que entre em detalhes sobre as Políticas. Este estudo analisa e compara as Políticas de Fogo Controlado em Portugal, Espanha e Itália, enfatizando os seus elementos-chave.

Apenas Portugal tem um quadro legislativo nacional para o FC; em Espanha e em Itália, o FC é regido principalmente a nível regional. A Catalunha-Espanha, tem um decreto-lei de 2005 bastante abrangente sendo a região autónoma espanhola com as regras mais rigorosas. Em Itália, leis recentes nas regiões italianas da Campânia e Apúlia foram aprovadas exclusivamente para o controle do FC. As restantes regiões espanholas e italianas regulam o FC por leis ou planos de gestão de incêndios florestais, com diferentes graus de restrição. As diretivas técnicas para as operações de FC variam regionalmente em função das condições geográficas locais. Apenas as leis Catalã e Portuguesa definem a formação necessária para o pessoal qualificado para o FC, enquanto nas outras regiões a identificação do pessoal autorizado não é clara. O estudo também discute a implementação do FC no contexto Agro-pastoril.

O estudo identifica quais os modelos regulamentares que mais contribuem para a implementação do FC, enquanto aponta as lacunas nos quadros jurídicos do FC na Europa Mediterrânica.

Palavras-Chave: Fogo controlado, Legislação, Portugal, Espanha, Itália

RESUMO ALARGADO

Nas últimas décadas, o sul da Europa tem experienciado incêndios rurais de grandes dimensões e impactos elevados. Todos os anos, estes incêndios rurais causam danos significativos tanto para o ambiente como para a sociedade. Com a perda de milhares de hectares de floresta, danos na propriedade privada e, mais tragicamente, a perda de vidas humanas, são necessárias ações urgentes para a prevenção e mitigação de tais eventos.

O fogo controlado (FC) é uma técnica utilizada para a prevenção e redução de incêndios florestais. Esta técnica consiste em acender intencionalmente um fogo para reduzir a elevada carga de combustível / biomassa acumulada, sob as condições meteorológicas específicas e a supervisão constante de uma equipe especializada, geralmente técnicos florestais, bombeiros, sapadores florestais, para acompanhar a queima e impedir a propagação de qualquer fuga desta. O FC é sempre realizado sob condições meteorológicas e ambientais específicas, incluindo baixas temperaturas, humidade elevada do combustível e do ar, direções e intensidades favoráveis do vento, etc.; isso permite um maior controlo sobre a intensidade da chama, velocidade e o que se pretende queimar. Essas condições permitem igualmente minimizar os impactos no solo e na fauna.

O FC é amplamente utilizado também para atingir vários objetivos de gestão florestal, incluindo conservação da biodiversidade, controle de infestantes, pragas, insetos e espécies invasoras, tratamentos silviculturais, aberturas de terras, e renovação das pastagens.

Esta técnica proporciona os resultados mais satisfatórios quando aplicada em ecossistemas adaptados ao fogo, pois simula os regimes naturais de fogo e reintroduz o elemento fogo no ambiente de forma sustentável. Portanto, esta prática poderia ser facilmente aplicada no contexto do sul da Europa, uma vez que o fogo vem moldando os ecossistemas desta região há vários milénios.

Já existem amplas evidências e investigação que apoiam os benefícios do FC para os ecossistemas mediterrânicos. Apesar das claras vantagens da aplicação do FC em ecossistemas adaptados ao fogo na Bacia do Mediterrâneo, esta prática não é usada de forma homogénea no sul da Europa nem de forma igual dentro do mesmo país. Existem, de facto, vários fatores e constrangimentos que podem limitar a extensão da aplicação do FC. Além disso, uma tendência geral nos planos de gestão de incêndios florestais em toda a Europa é excluir o elemento fogo dos ecossistemas naturais, mesmo os do Mediterrâneo, onde o fogo teve um impacto evolutivo substancial, e dar maior ênfase à supressão de incêndios florestais do que à prevenção.

Uma das principais limitações do uso do FC são os marcos legislativos que regulamentam os planos de gestão dos incêndios rurais e o uso do fogo em áreas arborizadas. De facto, cada

país escolhe uma estratégia legislativa distinta para o uso do FC. Os regulamentos diferem em termos organização das queimas bem como das instruções técnicas específicas para a implementação do FC.

O objetivo deste estudo é analisar e comparar o estado da arte da legislação do uso do fogo controlado em três países do sul da Europa: Itália, Espanha e Portugal. Pretende-se destacar as principais características, como diretrizes operacionais e restrições para intervenções de FC, objetivos, a identificação de pessoal qualificado e os regulamentos para aplicação do FC no contexto agro-silvo-pastoril.

Os resultados mostraram que Portugal é a única nação até à data, a ter implementado um quadro estatutário nacional abrangente para a regulação da FC. Tanto em Itália como em Espanha, a legislação relacionada com o fogo controlado existe de forma independente nas suas regiões autónomas.

A Catalunha é a Comunidade Autónoma de Espanha que regulou com maior rigor o FC, tendo aprovado um Decreto-Lei que estabelece orientações detalhadas e específicas para a gestão do FC na Região. Na Cantábria, foi aprovado um decreto específico para o uso do fogo controlado, portanto, tanto a queimada prescrita como a queimada tradicional nas atividades agro-pastoris, que prevê algumas regulamentações para o FC. As regiões autónomas das Astúrias, Galiza, Madrid e Extremadura, têm a regulamentação para o uso do fogo em conjunto com as legislações de gestão de incêndios florestais. As políticas de gestão do fogo das Ilhas Baleares, Aragão, Castilla La Mancha, Castilla y Leon, Múrcia e Navarra, só permitem o uso do FC, unicamente em circunstâncias excecionais, e quase não fornecem qualquer tipo de diretivas técnicas para a sua utilização. Não foram encontrados marcos legislativos para FC na Andaluzia, Valência, La Rioja, País Basco e Ilhas Canárias.

Na Itália, apenas as Regiões da Campânia e Puglia estabeleceram leis regionais específicas que controlam apenas o uso do FC. As leis regionais da Lombardia, Piemonte, Ligúria, Toscana, Abruzzo, Basilicata e Calábria tentam abordar o FC; no entanto esses regulamentos apenas permitem o uso do FC, para determinados fins, e não descrevem instruções operacionais específicas. Em Emilia Romagna, Molise, Sicília e Sardenha, o FC é discutido somente nos seus Planos Regionais de Prevenção de Incêndios Florestais. O FC é regulado de forma diferente por cada um dos planos individuais, e as diretrizes técnicas para tais operações são geralmente inconsistentes. Cinco, das regiões italianas, não possuem qualquer regulamentação legislativa para o FC (Veneto, Friuli Venezia Giulia, Trentino Alto Adige, Marche e Umbria).

De um modo geral, o principal objetivo das políticas do FC é a prevenção de incêndios florestais, seguido da gestão da paisagem, da gestão das pastagens e da investigação

científica. Outras finalidades incluem oferecer oportunidades para os bombeiros receberem formação, erradicar pragas e doenças, abrir espaços para as terras agrícolas, manter aceiros e proteger as interfaces rural-urbanas. Esses objetivos, no entanto, são menos típicos e são encontrados principalmente nas legislações Italianas e Espanholas.

Devido às variações regionais de geografia e clima, existem diferentes modos de operação para queimadas prescritas, a maioria das quais são específicas para cada queima prescrita individual. O Plano Técnico, que deve sempre incluir a área da queima, os objetivos do fogo, a vegetação a ser queimada e o pessoal que participará da queima, é exigido para cada operação de queima prevista, de acordo com todas as leis aplicáveis.

Embora não haja uma época comum permitida para o FC, a maioria dos estatutos atribui a época adequada entre outubro e abril, com casos excecionais que permitem o FC durante todo o ano (por exemplo, Catalunha).

As pessoas autorizadas identificadas para realizar FC também diferem entre os territórios analisados. Os critérios de formação específicos para a credenciação de indivíduos em Fogo Controlado são exigido apenas em Portugal e na Catalunha. Além disso, Campânia e Puglia declaram na sua legislação que somente funcionários que tenham adquirido a formação necessária podem realizar operações de FC, mas não especificam as características especificas dessa formação.

A maioria das leis analisadas aplica as regras gerais aplicadas ao FC quando se trata da sua aplicação em ambiente agropastoril. No entanto, os quadros legais em Portugal e na Cantábria permitem aos interessados a realização de queimadas extensivas com recursos próprios para regeneração de pastagens ou gestão de terras agrícolas. A Cantábria não exige a supervisão de uma figura profissional desde que o responsável pela queima tenha passado por um curso básico de gestão de incêndios oferecido pelo departamento regional responsável. Em Portugal, estes tipos de queimadas extensivas requerem apenas a presença de um operador credenciado em FC, ou outro pessoal qualificado (como um corpo de bombeiros).

Em conclusão, este estudo contribui para um conhecimento mais profundo dos sistemas jurídicos que atualmente regem o FC no sul da Europa. Portugal e a Catalunha oferecem os exemplos mais ilustrativos de regulamentação legislativa do FC. O FC começou a ser regido por regulamentos mais específicos nos últimos anos, como testemunhado na Cantábria, Campânia e Puglia. O FC deve sempre ser regulada de acordo com o ambiente em que é utilizado. Mas a ausência de um único marco regulatório nacional para o FC em Espanha e em Itália leva a uma compreensão fragmentada da ideia de queima prescrita, conforme visto

pelos padrões, objetivos e identificação díspares de pessoas autorizadas nas várias regiões italianas e espanholas.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AIB Plan- Forest Fire Prevention Plan

ANEPC- National Emergency and Civil Protection Authority

DMC- Duff Moisture Code

DRE- Diário da República Electrónico

EAFRD- Regulation on support for rural development by the European Agricultural Fund for Rural Development

EB- Extensive Burning

EFFIS- European Forest Fire Information System

EU- European Union

FC- Fogo Controlado

FFMC- Fine Fuel Moisture Code

FWI- Fire Weather Index

GRAF- Group of Support to Forest Actions

ICNF- Institute for the Conservation of Nature and Forests

INFOMA- Special Emergency Civil Protection Plan for Forest Fires in the Community of Madrid

ISPC- Institute for Public Safety of Catalonia

PB- Prescribed Burning

PREIFEX- Plan of Forest Fires Prevention in Extremadura

SGIFR- Integrated rural fire management system

1. INTRODUCTION

In recent years, fire regimes in Southern Europe have experienced significant changes, with wildfires becoming more recurrent, severe, and larger (Fernandes, 2013). Every year, large wildfires cause economic losses and disruptions to ecosystem services in at various Southern European countries, alongside excessive human fatalities and damages to private properties (Moreira et al., 2020; Papakosta et al., 2017).

The underlying cause beneath this transition is a combination of climatic and socioeconomic factors and changes that have occurred in the last few decades in the Mediterranean Basin. The rise in global temperatures and the prolonged summer droughts have largely contributed to the increase of large wildfires and of risk of ignitions (Williams et al., 2019).

This shift in the fire regimes can be further explained by certain socio-economic developments that have taken place in Southern Europe in the last fifty-seventy years. The rapid economic growth that interested the region in the second-half of the 20th century led to a mass migration from the rural areas to the urban and peri-urban ones, in search of higher incomes' opportunities (Kerckhof et al., 2016). As a result, agricultural and pastoral activities were lost at a large scale across Southern Europe, and landscapes that were previously managed and shaped by the local communities were abandoned. These demographic changes led to a significant accumulation of vegetation and afforestation, whilst promoting landscape connectivity (Cervera et al., 2019; P. M. Fernandes et al., 2019). The buildup of biomass fuel has additionally contributed to the growth of wildfires, alongside the recent climate changes (Pausas & Millán, 2019).

Just in the last century, fire regimes in Southern Europe have shifted from fuel-limited to drought-limited, due to the combination of these factors (Pausas & Fernández-Muñoz, 2012). Therefore, urgent action is required to cease these financial and environmental losses. The greatest way to lessen the effects of wildfires is to prevent them in the first place, as opposed to responding to them after they have already started.

Among all wildfire preventive measures, prescribed burning (PB) is considered one of the most adequate ones in the Mediterranean context, due to its high efficiency and adaptability in fire-prone ecosystems In PB, accumulated biomass is intentionally ignited, under specific environmental conditions and with the supervision of firefighters, to limit the size and intensity of future wildland fires (Australian Fire and Emergency Services Authorities Council, 2015).PBs are usually patchy and have low-intensities, and only reduce biomass fuel, either

in the understory vegetation in forests or above ground in shrublands, including shrubs, grasses, litter, and woody vegetation (Arkle et al., 2012).

PB effectively prevents the evolution of wildfires, by reducing cumulative vegetation that could potentially ignite into a large, severe, and harmful fire. Stands where PBs have been applied, in fact, present changes in forest fires' behavior, with lower intensities and reduced expansions (Fernandes, 2015). Wildfires occurring in prescribed burned areas are also easier to control and suppress (Fernandes & Botelho, 2003)..In addition, PB represents an important forestry treatment; in fact, it aids in a number of forest management objectives, including biodiversity conservation, control of weeds, pests, insects and invasive species, and land openings (Fernandes & Botelho, 2003).

PB falls into the category of controlled fire, includes flames that have been started on purpose to fulfill a specific achievement (Figure 1).

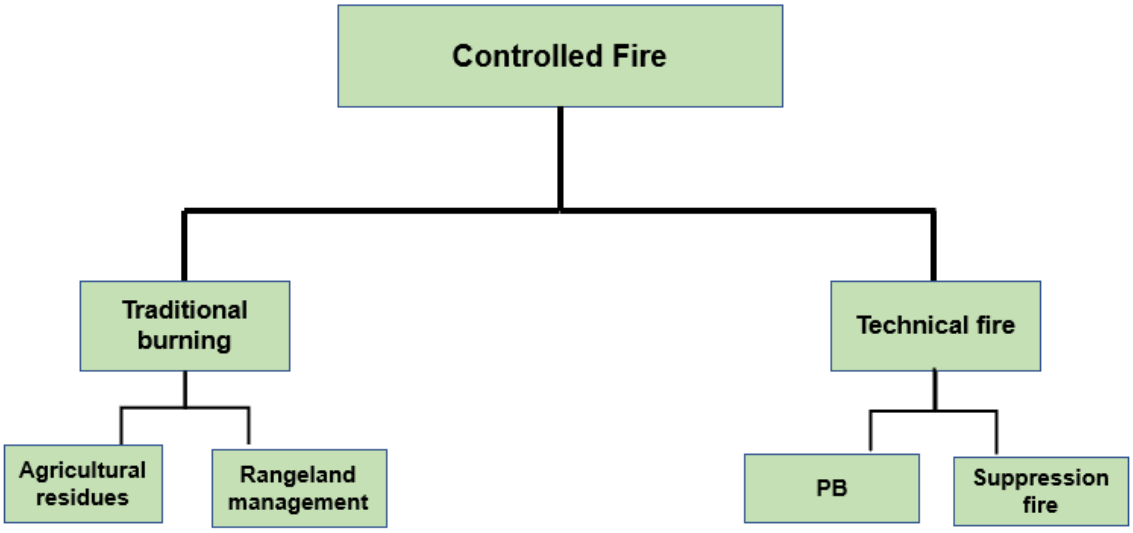

Figure 1: Types of controlled fire.

Prescribed fire specifically belongs to the category of technical fire, which also covers the deliberate igniting of fire to fulfill goals by qualified staff trained in fire management. Suppression fire belongs to the category of technical fire along with PB: this technique consists of igniting a fire line during a forest fire event in a strategic position, and to control its direction either to reduce the biomass fuel ahead of the wildfire's advancement or to counteract the main fire itself (Miralles et al., 2010).

The other type of controlled fire consists of the use of fire in the agro-silvo-pastoral context, including the burning of residues from agricultural activities and the maintenance of rangelands. The latter objective, however, has mostly been added into PB because it relates to land management goals and also aims to limit the frequency of wildfires caused by uncontrolled pastoral burnings (Lambert, 2010; Ruiz-Mirazo et al., 2012).

It is crucial that PB interventions are carried out by qualified persons who have acquired the most adequate training for such practice for them to be a successful tool for fuel treatment and landscape management; this is mainly because PB operations carry a great deal of liability and they must be closely monitored to avoid fire escape and the formation of large wildfires (Miller et al., 2020). Programs for prescribed burning are not uniform in structure across the globe, but they often concentrate on fire ignition methods and fire control through both theoretical and practical modules, with the latter one typically receiving greater attention (Derek Scasta et al., 2015)
PBs themselves also represent a great educational opportunity for firefighters to enhance their fire management and extinction skills (Metallinou, 2020).

There is extensive evidence that demonstrates the positive effects of PB on the biodiversity of fire-adapted ecosystems. Prescribed fires, in fact, can increase native plant species biodiversity, and the diversity of successional stages in vegetation (Murphy et al., 2015; Zald et al., 2020). Prescribed burning improves the quality of the understory vegetation by reducing the surface fuel load, which further improves biodiversity by attracting bees and other flower-visiting insects. (Campbell et al., 2018). PB can benefit the fauna as well by opening the landscape for grazing, browsing, and hunting (Fernandes et al., 2013). On the long-term scale, soils are also positively influenced by PB; PB locations typically have soils with better quality, sorption capability, and microbial community expansion. (Francos & Úbeda, 2021).

Nowadays, prescribed burning is widely used in fire adapted ecosystems worldwide, especially in countries with Mediterranean climate and vegetation, as an alternative fire management strategy and landscape management tool. (Bradshaw et al., 2018).
PB, for instance, is the only method currently available in Australia that successfully reduces the risks associated with wildfires, and Aboriginal populations have always controlled fire to open forests and to form grazing lands, establishing a traditional fire management regime that is still in place today (Morgan et al., 2020).
Studies in California have demonstrated how conifer stands treated with PB displayed fewer injuries in the tree crown from wildfires, in comparison to untreated stands (Fernandes and Botelho, 2003)

PB represents a successful fuel reduction tool in these regions because it emulates their natural fire regimes. Prescribed fires are usually patchy and have low-intensities, and only reduce the understory fuel, including shrubs, grasses, litter, and woody vegetation (Arkle et al., 2012).

In Mediterranean Europe, wildfires are a very common natural disturbance, and they have been shaping its terrestrial ecosystems for several millennia (Santos & Cheylan, 2013). As a result, today the macro-region features a wide variety of vascular plants, thanks to the selection applied by fire (Rundel et al., 2018). Most of the present Mediterranean plants and trees display adaptive traits evolved from fire resilience, including: fire resistant tissues (e.g., thick barks) succulent tissues rich in water, post-fire resprouting of the meristematic tissue, serotiny, with seeds kept in the canopy and germination triggered by heat, as well as flowering brought on by fire (Rundel et al., 2018).

Additionally, Southern Europe has a long history of the anthropogenic use of fire from its communities. Throughout the centuries, the Mediterranean populations have shaped the landscape by burning the natural vegetation for various intents, involving pastures' regeneration, clearing the land for crops, roads and hunting, and the removal of threatening plant and animal species (Pausas and Fernández-Muñoz, 2012). Pastoral burnings have become a regular activity for land management in rural areas of some parts of Southern Europe, and they're still actively performed to this date; (Fernandes et al., 2013; Ruiz-Mirazo et al., 2012).In France, for example, the pastoral communities of the French Pyrenees have a long history of using fire to manage and improve their rangelands, and have become part of the country's PB framework (Fernandes et al., 2013). Therefore, PB has the right potential to be applied in this region, due to the adaptability to fire of its ecosystems.

Nowadays, there is comprehensive information on the use, the outcomes, and the advantages of PB in Mediterranean European countries.
Moya et al., 2021, for example, demonstrated how prescribed fires in Mediterranean mixed-pine forests do not negatively impact the microbial communities of the soil. Fuentes et al., 2018 proved that in an Aleppo pine (*Pinus halepensis*) stand in Northeastern Spain repeated prescribed fires do not alter the understory plant community, whilst also keeping highly flammable seeder species under control. In Spain, low intensity prescribed burnings effectively reduce the risk of wildfire hazard and do not alter the Black pines' (*Pinus nigra*) growth rate (Espinosa et al., 2021). In the French Pyrenees, prescribed burning also implements traditional pastoral burnings, thus including the local communities in the land management and reviving the rural areas (Fernandes et al., 2013).

All the evidence mentioned above suggest that PB is certainly a useful mean for wildfire prevention, especially in the case of Mediterranean Europe. Yet, PB is not equally applied and implemented across Southern Europe; in some areas of Southern Europe, PB is not practiced as desired and to the necessary extent to significantly reduce wildfire hazard, despite its potential, due to a series of challenges and limitations. Instead, in other parts of the region PB is extensively used as a fire prevention and land management tool. Legislative frameworks that regulate the use of fire in forested land are among the key factors limiting the use of PB (Galiana and Lazaro, 2010).It is important to acknowledge the complexity of the policymaking processes, and the pre-existing conditions that can affect them. In the case of policies related to PB in Southern Europe, the legislations differ from country to country, mainly due to historical, social, and legislative factors.

The historical, social, and legislative backgrounds have significantly affected the policies concerning PB in Southern Europe. PBs started to be applied in Europe during the second half of the 20th century, whilst in the Mediterranean area the first experimental trial was carried out in Greece in 1960s (Fernandes et al., 2013). However, it was not before the end of the 1970s that prescribed burnings were applied as a land management tool (Ascoli and Bovio, 2013). PB started to be employed as a fuel treatment during the 80s and the 90s, with the first programmes implemented in France, Portugal, and Spain (Ascoli and Bovio, 2013). At first, PB was exclusively used to reduce fuel in the understory vegetation; but then, throughout the years, researchers started to understand its importance for wildlife management and biodiversity conservation. With the rise of scientific interest around PB, more Southern European countries started to include prescribed burning in their legal framework, but not all to the same extent.

In general, forestry-related policies vary from one nation to another due to a number of local and national factors.

For instance, in any country, research efforts, can heavily impact the formulation of policies related to forestry. Decisive scientific findings, in fact, can have a major impact on the policy making process, and ultimately be included into the normative framework (Spilsbury & Nasi, 2006). However, the dialogue between scientists and policy makers has always been heavily obstructed, mainly by different attitudes, and interests, especially political and economic; this results into severe delays in the whole decision-making process (Spilsbury & Nasi, 2006). Prior to incorporating a certain forestry practice into legislation, the available scientific knowledge must always be highly reliable. (Spilsbury & Nasi, 2006).

In relation to PB, research efforts haven't been consistent across Southern Europe, which can explain why in some countries this technique is more implemented in their legal framework than others (Fernandes et al., 2013).

It is also very common to see conflict of interest among the different parties involved in any decision-making process, especially in forest policy. Stakeholders, forest managers, policy makers, etc., tend to have different priorities and objectives when discussing the use and conservation of forests and natural areas (Gritten et al., 2013; Zachrisson & Beland Lindahl, 2013).
For instance, the exponential demographic growth and residential development around areas with high fuel loads have also prevented prescribed burning from being applied more regularly and frequently in the macro-region (Ascoli and Bovio, 2013; Haines et al., 2001).

It is also important to state that within the European Union (EU) there is no common European policy for forestry; each Member State formulates its own forestry policies, and abides by them (Edwards & Kleinschmit, 2013). Common European policies would promote international coalition and support at a scientific level, which would represent a crucial aid when addressing the issue of forest fires in Europe (Besenyő, 2019; Winkel & Sotirov, 2016). Southern European countries have expressed their support in favour of a common European forest policy, mainly, because it could provide financial aid for the rural areas, where forest fires are the most frequent (Winkel & Sotirov, 2016). Regarding forest fires and the use of fire in natural areas, the European Commission has established different schemes and support systems to prevent wildfires and to recover the damages that they cause. For the prevention of large forest fires, the most important action taken by the EU Commission is the “Regulation on support for rural development by the European Agricultural Fund for Rural Development” (EAFRD) (European Union, 2013). The EAFRD supplies the legal foundations for fire prevention practices, and it grants financial support for fire prevention measures in rural areas with a higher risk of forest fire; however, it is left to each Member State to choose which fire prevention measures to implement, and PB is not specifically discussed in the regulation.

The societal negative perception of fire has also somewhat impeded the application and integration of PB in the legal frameworks of certain Southern European and other regions worldwide.
In the United States of America, for example, concerns have been raised on whether smoke plumes from PB can negatively impact air quality and human health, although evidence suggest that fine particulate matter from wildfires’ smoke are far more hazardous (Jaffe et al., 2020; Liu et al., 2017). In some countries and regions in the world, air quality laws have prevented PBs from being applied in open areas, and there is still much debate on the possible impacts of smoke from prescribed fires on human health (Haikerwal et al., 2015; Haines & Cleaves, 1999). There’s also an important risk of liability that must be considered when it

comes to PB and air quality legislations. The concernment for liability has reduced the use of PB in many areas, and, thus, its inclusion in the legal frameworks (Haines et al., 2001).

However, for some Southern European countries, the most significant barrier to PB deployment has been the general and legislative attitude to fighting forest fires. For decades fire has been perceived by the European forestry bodies as a destructive element in the natural landscape; this was brought on by the careless or deliberate use of fire in forest areas, resulting in too stringent rules and policy frameworks for its usage (Lambert, 2010). As a result, the forest management divisions have also placed an overwhelming emphasis on wildfire suppression rather than prevention (Xanthopoulos et al., 2006). Excluding fire from ecosystems that have adapted to it, like those in the Mediterranean Basin, is a detrimental practice because it causes an unsustainable build-up of biomass fuel, which inevitably leads to larger and more intense wildfires and dramatic changes in the natural fire regime (Donovan & Brown, 2007). In order to overcome rigidly constructed legal frameworks to restrict fire use, or the complete lack of legal regulations for its usage, appropriate legal frameworks for PB and fire control must still be developed in some Mediterranean European nations (Lambert, 2010).

Overall, this series of factors, challenges and limitations has severely influenced the formulation of legislations concerning prescribed burning in several countries in Southern Europe, leading to heterogeneity in PB regulatory frameworks across the macro-region. Some of the EU Member States in the Mediterranean have successfully implemented PB in their statutory framework and apply it on a regular basis. In other Mediterranean European countries, however, PB is scarcely regulated, and it is not applied to the desired degree. It is necessary to evaluate the policies of the individual states, and their restraints, to improve whereas is necessary.

There is some general knowledge regarding the legislative status of PB in Southern Europe, but there is little information and debate on the policies themselves on an international level. Currently, there is no study that provides a detailed review on the exact regulations on PB in Southern Europe, and on the training programs available for PB personnel. There isn't a comparative study that examines how PB regulations vary across Mediterranean Europe, in particular.

The aim of this study is to examine and compare the state of the art of PB legislations in Italy, Spain, and Portugal, three Mediterranean European countries where PB is applied, by focusing on key elements like operational guidelines and restrictions for PB interventions, objectives, the identification of qualified personnel, and the regulations for PB application in the agro-pastoral context.

2. METHODOLOGY

2.1 Legislative review

This study was carried out by performing a qualitative comparative analysis of the legislations that are currently regulating the use of PB in Portugal, Spain, and Italy.

Each relevant legislation was thoroughly scrutinized in order to understand how PB is specifically administered in each country.

To assess the policy differences among the three countries, two main features of PB regulations were evaluated. The first aspect considered was the type of policy adopted by each country, or region, to regulate PB. The policy type meant whether it was a policy expressly designed solely for PB, or a general fire management (FM) scheme or policy, that also included the regulation of PB among other wildfire preventive measures. In case the PB regulations were part of a FM plan or policy, it was also considered how much of the scheme covered the use of PB, whether entire chapters, short paragraphs, or simply mentions. Analysing the policy type helps to better understand the approach of the country or region towards PB; it can also reflect how extensively PB is regulated.

The second feature assessed for all the legislations, was their content and how specifically they administered PB. Different factors were evaluated when assessing each PB policy, including for which purposes PB is applied, the modalities for its safe execution, what are its restrictions, who is authorized to perform PB, and how the use of fire is regulated in agricultural and pastoral activities for wildfire prevention and land management purposes (Figure 2).

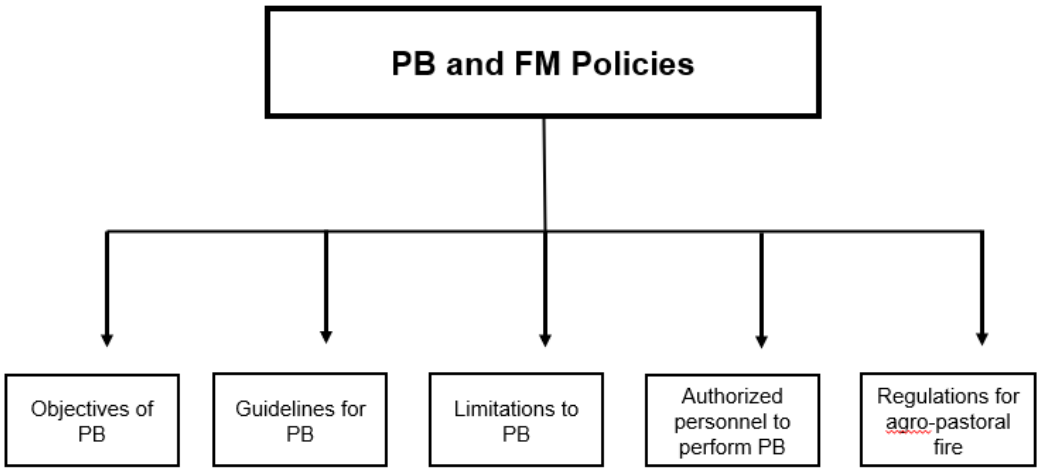

Figure 2: Scheme of the research for PB policies in Portugal, Spain, and Italy (PB- Prescribed Burning; FM-Fire Management).

For all the three states, only the latest decree-laws were analysed since the aim of this study is to assess the legislations that are currently in place. For each country, the relevant documents were searched through the online portals of the authorities responsible for PB and forest fire prevention. Each country required a different method of research, due to the differences in the political structure of the three countries.

Furthermore, the study also assessed the different technical training programs that are used to form authorized personnel for PB across Portugal, Spain, and Italy. For each technical training program for PB, certain factors were taken into account, including the entity that currently administers the programs, how many hours are dedicated to PB, the teaching modalities, the content of the courses, and what kind of certification they provide to the trainees (Figure 3).

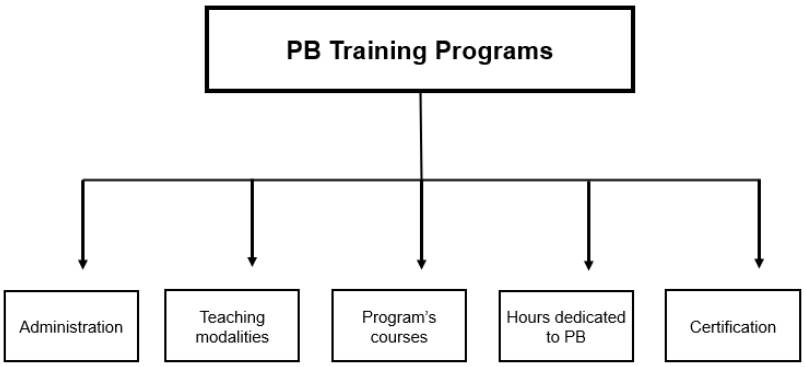

Figure 3: Scheme of the research for PB training programs in Portugal, Spain, and Italy

2.2 Portugal

Since in Portugal forestry policy is mainly administered on a national level, the documents of the current regulations concerning PB were accessed through the "Diário da República Electrónico" (DRE) (English: Electronic Republic Gazette), the online portal of the official journal of the Portuguese Republic, where all national legislations can be consulted and retrieved freely by the public.

For consulting the training programs delivered in Portugal to train authorized personnel for PB, the necessary documents were found on the website of the "Institute for the Conservation of Nature and Forests" (ICNF), which is one of the institutions responsible for wildfire management in Portugal and the responsible for forest management.

All the documents mentioned above were analysed in Portuguese.

2.3 Spain

Although Spain is a unitary state, it is known to be one of the most decentralized countries in the European Union, due to its organisational structure as an alleged “State of Autonomies”; formed by 17 autonomous communities, each community has a set of devolved powers, and its own government and public administrations, including those governing forestry. Furthermore, the “Law 43/2003, of November 21” instructs all the autonomous communities to regulate the use of fire in forests and other preventive measures by legislative measures through their competent departments. Therefore, PB policies in Spain had to be researched at a regional level, through the online portals of each autonomous community’s division related to forest management and wildfire prevention (Table 1). Different types of documents were searched through the portals, including all orders, resolutions, decrees, and regional plans that rule the use of fire in forested land and/or wildfire prevention.

Table 1: Departments responsible for PB regulation in the Autonomous Communities of Spain

Autonomous Community	Competent Department/Ministry
Andalucía	Ministry of Environment
Aragon	Department of Rural Development and Sustainability
Asturias	Ministry of Rural Development, Farming, and Fisheries
Cantabria	Ministry of Rural Development, Livestock, Fisheries, Food and Environment
Castilla-La Mancha	Ministry of Environment and Rural Development
Castilla y Leon	Ministry of the Environment, Housing and Territorial Planning
Cataluña	Environment Department
Madrid	Ministry of Economy and Technological Innovation
Comunidad Foral de Navarra	Ministry of Rural Development, Environment and Local Administration
Comunidad Valenciana	Ministry of Agriculture, Environment, Climate Change and Rural Development
Extremadura	Ministry of Environment and Rural, Agrarian Policies, and Territory
Galicia	Department of the Rural Environmentl
Islas Baleares	Ministry of Environment
Islas Canarias	Ministry of Ecological Transition, Fight against Climate Change and Territorial Planning
La Rioja	Ministry of Sustainability and Ecological Transition
Pais Vasco	Department of Economic Development, Sustainability and Environment
Principado de Asturias	Ministry of Rural Development and Natural Resources
Region de Murcia	Ministry of Agriculture and Water

Moreover, Spain also includes two autonomous cities in the Mediterranean coast of Morocco, Ceuta and Melilla. The Law 43/2003 grants them as well the same duties as the ones granted to the Autonomous Communities regarding forest management and wildfire prevention. For that reason, current PB policies in Ceuta and Melilla were searched through the online portals of their government’s departments competent for forestry, just as it was done for the autonomous communities (Table 2).

Table 2: Departments responsible for PB regulation in the Autonomous Cities of Spain

Autonomous City	Competent Department/Ministry
Ceuta	Ministry of the Environment and Urban Services
Melilla	Ministry of the Environment and Sustainability

The regulations for PB training programs were also searched individually for each Spanish Autonomous Community or City. The programs' contents, structure, and organization were searched through website of the competent departments listed in Table 1 and Table 2.

The PB policies and the training programs for PB across the autonomous communities and cities of Spain were reviewed in either Spanish, Catalan, or Galician.

2.3 Italy

The research for PB policies in Italy had to be done both at a national and regional level. Italy is a regionalised unitary state, meaning that it is overall a unitary state, but with certain degrees of political power distributed to the regional administrations, including forestry as well, but not the same extent as the Spanish autonomous communities. Italy is formed by twenty regions, of which five have been given a "special statute" of autonomy, implying that they have more legislative, financial, and administrative authority, regarding forestry as well (

Table **3**). As a result, forestry policy in Italy is generally fragmented across the country, there is a lack of a solid national forestry system, and wildfire prevention plans are mainly formulated regionally

Table 3: Statute of the Italian regions.

Region	Statute
Abruzzo	Ordinary
Basilicata	Ordinary
Calabria	Ordinary
Emilia-Romagna	Ordinary
Friuli-Venezia-Giulia	Special
Lazio	Ordinary
Liguria	Ordinary
Lombardy	Ordinary
Marche	Ordinary
Molise	Ordinary
Piedmont	Ordinary
Puglia	Ordinary
Sardinia	Special
Sicily	Special
Tuscany	Ordinary
Trentino Alto-Adige	Special

Umbria	Ordinary
Valle d'Aosta	Special

Policies concerning the regulation of PB in Italy were analysed both nationally and for each region. To evaluate PB policies in Italy, legislations were accessed both through national and legislative portals.

The national policy regulating PB in Italy was retrieved from the online archive of the “Gazzetta Ufficiale della Repubblica Italiana” (English: Official Gazette of the Italian Republic), by searching the latest measures adopted for wildfire prevention in the country.

For PB policy across the Italian regions, the procedure differed from the policy research for the Spanish autonomous communities. The regional legislation of the environmental and forest fire prevention sector provides for administrative procedures to authorize PB interventions in the Italian regions. Instead of being disclosed through the online portals of the regional department competent in forest fires, the legislative collections of the individual regions are published on the websites of the regional legislative assemblies.

The PB training programs are also a specialty of the specific Italian region. Since regional councils oversee the implementation of such programs, their online portals were also checked for pertinent information.

All the legislations and training programs related to PB in Italy were reviewed in Italian.

3. RESULTS

3.1 Legislative frameworks

The legislative analysis of PB policies in Portugal, Spain, and Italy has demonstrated that there are significant differences in the legal systems of the three nations.

To this date, Portugal is the only country, so far, that has implemented a legislation that regulates PB at a national scale, while Spain and Italy administer PB mostly on a regional level.

In Portugal, PB is governed by a comprehensive legislative system. Two main statutes have been found to regulate the application of PB in continental Portugal (Table 4).

Table 4: Legislative framework of PB in Portugal.

Legislation	Regulations for PB
Order No. 7511/2014	Defines authorized personnel for PB and outlines training programs in PB. It addresses the full regulation of PB in Portugal
Decree-Law No. 82/2021 of 13 of October	Establishes the Integrated rural fire management system (SGIFR) Identifies the responsible institutions for PB operational directives

These two policies ensure an all-inclusive legislative regulation for PB in Portugal, with technical insights for the entire procedure of PB, from the drafting of the proposal plan to the modalities for PB interventions.

The Order No. 7511/2014 identifies the required training programs that authorized personnel for PB in Portugal, and what exactly defines as authorized personnel for each role in a PB operation. In addition, the Order describes into details the formulation process and the content of the proposal plan for an PB intervention. The Order follows the “Decree-Law n. 124/2006 of June 28” (National System of Forest Defense against Wildfires), with the changes here listed (n. 15/2009 and 17/2009, of January 14, n. 114/2011, of November 30, and n.83/2014, of May 23).

The Integrated rural fire management system (SGFIR), which was enacted with the Decree-law n. 82/2021 of 13th of October, is a program that implements a comprehensive wildfire prevention strategy at national, regional, and municipal levels; due to their autonomy from Portugal's mainland and their distinct terrestrial ecosystems, the decree-law really doesn’t apply to the archipelagos of the Azores and Madeira.

The SGIFR consists of a set of structures, norms, and processes on an institutional basis in the integrated management of rural fire. It proposes modern alternatives for the prevention of wildfires, especially regarding land use planning, forest management, and fuel management. The SGIFR dedicates a broad section on the regulation on the use of fire in forested land, including technical fire and agro-pastoral burnings. The system authorizes the practice of PB as fuel management tool in regional and sub-regional wildfire management plans. In these programs, PB regulations can be administrated by both the ICNF and the National Emergency and Civil Protection Authority (ANEPC). The section provides for some guidelines for the application of PB on a general note, but the technical instructions and functions for are defined by specific regulations approved by the ICNF.

The SFGIR also institutes a set of regulations for the use of fire in agricultural and pastoral activities, like for the regeneration of pastures or land clearing for growing crops. In Portuguese, these types of burnings are known as “queimadas”. Unlike PB as a fuel management tool, the precise guidelines for queimadas are not given by the ICNF (only general guidelines), but its competence of the local authorities (e.g. municipalities), which can formulate a series of norms depending on the characteristics of each queimada, including its plan proposal, the landscape, the meteorological conditions, etc.

In Spain, the legislative framework for PB is highly variable since the policy-making process is on a regional basis (Table 5).

Table 5: Legislative framework for PB across the Autonomous Communities of Spain.

Autonomous Community	Legislation	Regulations on PB
Andalucia	Decree-law 247/2001 of 13 of November *Modified by Decree-law 160/2016 of 4 of october*	Allows fire use only for burning for agro-pastoral activities and forest residues
Aragon	Order of 20 of February of 2015 *Temporarily extended by Orden AGM/112/2021*	Facilitates measures for fire use in agro-pastoral activities
Asturias	Resolution of 5 of March 2018	Regulate PB, agro-pastoral burnings and other wildfire preventive measures
Castilla-La Mancha	Order of 16-05-2006 *Modified by Order 26/09/2012*	Allows for PB as a silvicultural activity and wildfire preventive measure
Castilla y Leon	Order FYM/510/2013 of 25 June	Regulates fire use in forested landscape Sets out wildfire prevention activities Allows for PB as a fuel treatment and for phytosanitary purposes
Canary Islands	Decree-Law 146/2001	Regulates the use of fire in agricultural or forest estates
Cantabria	Order MED/3/2021	Regulates PB and the use of fire in agro-pastoral activities
Catalonia	Decree-law 312/2006 of 25 of July	Regulates the management of PB by the staff of the fire prevention and extinguishing services
Comunidad Valenciana	Order of 30 of March of 1994	Limits fire use only for agro-pastoral activities
Extremadura	Decree-law 260/2014 Order of 8 of October of 2021	Establishes Plan of Forest Fires Prevention in Extremadura (PREIFEX) Exceptionally permits PB as a forest fire preventive measure Designates annual orders to regulate the use of fire
Balearic Islands	Decree-Law 125/2007 of 5 of October	Regulates fire use Authorizes PB for wildfire prevention
Galicia	Law 3/2007 of prevention and defense against forest fires in Galicia	Sets out guidelines for PB authorization and application
La Rioja	Order STE/19/2021 of 20 of April	Regulates the use of fire only for agro-pastoral activities and for the burning of forest residues
Madrid	Decree-law 59/2017 of 6 of June	Authorizes and regulates the use of PB in the Special Emergency Civil Protection Plan for Forest Fires in the Community of Madrid (INFOMA)
Murcia	Order of 24 of May of 2010	Enables personnel assigned to the forest fire prevention and extinction services to Perform PB
Navarra	Foral Order 222/2016 of the 26 of June Foral Order 237/2017 of 4 of July	Enables qualified personnel to perform PB

Table 5 displays a wide range of different legislations regulating PB and the use of fire across the Spanish autonomous communities. Whilst almost all the regions order the use of fire in the context agro-pastoral activities, or for the burning of vegetal residues, not all of them permit the application of PB to manage biomass fuel and/or the landscape. The autonomous regions that discuss or regulate PB in their legislative frameworks are Aragon, Asturias, Castilla-La Mancha, Castilla y Leon, Cantabria, Catalonia, Extremadura, Galicia, Madrid, Murcia, Navarra, and the Balearic Islands.

Presently, there is no legislation that discusses PB for fuel treatment, or any other forestry purposes, in Andalucía, Valencia, la Rioja, and the Canary Islands; however, these regions regulate the use of fire only in agro-pastoral contexts that do not comply with the definition and objectives of PB. Some of these Autonomous Communities define this type of fire use as “controlled burning”, but it’s a deviant definition; in fact, the word "controlled" seems deceptive because it highlights how crucial it is to control the event rather than manage and steer it in accordance with the project's recommendations.

In the Basque Country there is no regulatory framework concerning PB, fire use, nor the prevention of forest fires. So far, the only legislative approach towards wildfires in the regions are decree laws that approve Special Emergency Plans and Civil Protection Plans, which mainly focus on fire suppression and early response to forest fires.

No regulations regarding PB and fire use in forested landscape were found for both the autonomous cities of Ceuta and Melilla.

In Spain, the autonomous communities govern PB through different normative frameworks, ranging from policies specifically designed to administer PB to regional forest fire management plans and/or legislations (Figure 4).

Figure 4: Legal framework for PB in Spain

Only Catalonia and Cantabria have established specialized statutes for PB as of yet. Catalonia has been one of the first Spanish communities to apply PB for a variety of purposes and to regulate it, with a decree-law that dates to 2006, and that has never been modified. The legislative framework governing technical fire in Catalonia offers a comprehensive and complete set of laws; with regards to PB, the act establishes clear guidelines on the prerequisites and the safety guidelines to carry out such a practice. The decree-law governs the use of backfire as well as prescribed burning since it is meant to administer the use of technical fire. This is the only policy in Spain to date that controls the management of technical fire and prescribed burning solely and fully.

Although the official name of the legislation in Cantabria is “Order MED/3/2021, of 9 of March, by which prescribed and controlled fires are regulated in the Autonomous Community of Cantabria”, this policy does not govern only PB and controlled fires, but also the burning of grasslands and shrubs for pasture and the burning of forest remains from silvicultural

treatments. Unlike the decree-law of Catalonia, this order is not intended to regulate technical fire in general, but to coordinate all uses of fire as a tool for managing the environment. Another difference that this order has when compared to the Catalan policy is its date of implementation. Cantabria, in fact, has just recently enforced this new order. These laws are the only ones in Spain to date that are intended to control just PB and fire use for land management purposes.

In the Balearic Islands, PB is regulated differently. The archipelago has passed in 2007 a decree-law exclusively to set norms for different fire uses that are susceptible to increase the risk of wildfire. The policy only devotes a brief piece to PB, which states that local Public Administrations with expertise in wildfires can eventually develop PB plans to reduce fuel load as a preventative strategy. It does not provide any directives for the procedure.

All the other regions of Spain that regulate PB, do so principally through their forest fire prevention campaigns and their wildfire management policies, although there is some variety in the degree to which PB is specifically and widely regulated in each of these regions.

For instance, the Community of Madrid regulates PB through its “Special Emergency Civil Protection Plan for Forest Fires in the Community of Madrid” (INFOMA), passed with the decree-law 59/2017 of 6 June. The INFOMA is a comprehensive fire management plan that outlines guidelines for preventing wildfires, detecting them early, and responding to them. The plan includes PB as one of its preventive and land management strategies. It specifies a wide variety of guidelines for PB, including who can conduct it, who oversees it, where it can be used, what kinds of vegetation can be burned, and which ignition methods are acceptable. Asturias as well regulates PB quite to the same extent as Madrid in its resolution, which was enacted with the goal to establish norms and regulates fire use in general for wildfire prevention.
Galicia has adopted the same legislative approach of Madrid to regulate PB, through its regional plan for prevention and defense against forest fires with the Law 3/2007. However, the plan regulates the permission process for PB rather than providing as many specific requirements for PB as the Community of Madrid's plan.
The PREIFEX plan in Extremadura allows for the application of PB, with exceptional character, and only during the season of low wildfire risk Although this is the only mention of PB in the plan, every year, the Autonomous Community issues a directive announcing the dates of the low-risk season and outlining the precise precautions to be taken for PB and other fire uses at that time. The latest measure, the Order of 8 of October of 2021, has circumscribed the application of PB only to areas with a high risk of wildfire in the natural areas of Jerte-Ambroz

and Vera-Tietar, whenever mechanization and access issues preclude conventional preventive forestry methods.

Forest fire prevention programs and defense strategies are also used to govern PB in Aragon, Castilla-La Mancha, Castilla y Leon, Murcia, and Navarra. However, these Regions do not control PB to the same extent as the aforementioned Autonomous Communities. All of these Regions allow the use of PB for preventing forest fires, regenerating pastures, training firefighters, etc.; nevertheless, their statutes do not outline any rules for its usage. In these situations, each PB is governed independently by the directions laid out in the burning plan and accepted by the appropriate authorities.

In Italy, the framework of regulations related to PB resembles more the one of Spain since it regulates PB mainly on a regional scale as well.

Due to the most recent national regulation of managing forest fires, the Law 8 September 2021, no. 120, with revisions from the Law 8 November 2021, n.155, PB is generally managed by the individual regions in Italy. The aim of this act is to install institutive actions to strengthen coordination and operational capacity in prevention and diligent fighting against forest fires in the country. The Act is meant to create an all-encompassing program to fight wildfires, however it mostly focuses on fire suppression rather than fire prevention. In actuality, the Law designates the different regional authorities to create their own forest fire prevention campaigns, through regional plans and policies, as opposed to developing a national program for the prevention of forest fires on a large scale.

The Law only enables the use of PB for treating fuel and preventing wildfires on Italian territory; it does not, however, regulate how it is used. It does, nevertheless, provide individual regions the option to integrate PB in their regional prevention plans and to create legislation to govern it. Because not all the Italian regions govern PB, and those that do employ various legislative tactics, PB is only regionally regulated in Italy. As a result, the legislative framework is extremely fragmented. Some regions have developed specific legislations to regulate PB, whilst others discuss and regulate PB in fire prevention statutes, and other regions set guidance for PB in their fire regional fire prevention campaigns (Figure 5).

Figure 5: Legislative framework for PB in Italy.

Currently, only Campania and Apulia have recently adopted specialized regulations to govern PB out of the twenty Italian regions (Table 6).

Table 6: PB Policies in Campania and Apulia

Region	Legislation	Regulations on PB
Campania	Regional Law 13 June 2016, n. 20 Executive degree of 22 December 2020, n. 341	Technical requirements and operating procedures inherent to the applications of PB
Apulia	Regional Law 6 August 2021, n. 4	Rules for the planned application of PB

Both regions have adopted a legislative approach specifically targeted to the regulation of PB, and these are the only ones present in Italy. The legislations of both Regions clearly define the conditions and norms for the application of PB, especially in Campania; the Executive degree of the region provides detailed information on which professional figures are involved, the operating procedures, the necessary meteorological and topographic conditions, etc. In Apulia, the Regional Law determines in which contexts PB can be performed, the parties involved and the limitations to its use. In contrast to the Region of Campania, Apulia does not have a set of standardized instructions for PB; instead, each burn is governed separately, according to the directives contained in the PB plan and the authorization given by the appropriate authorities.

Regional laws in Lombardy, Piedmont, Liguria, Tuscany, Abruzzo, Basilicata, and Calabria somewhat address the usage of PB (

Table **7**).

Table 7: Regional fire prevention laws in Italy that discuss PB

Region	Legislation	Regulations on PB
Abruzzo	Regional Law n. 4 of 2014	Allows the use of technical fire for wildfire prevention (PB) and suppression (backfire)
Basilicata	Regional Law n.13 of 2005	Grants exceptional permissions to perform PB under certain conditions
Calabria	Regional Law n. 51 of 2017	Authorizes PB for wildfire prevention and scientific research
Lazio	Regional Law n. 39 of 2002	Authorizes PB for wildfire prevention
Liguria	Regional Law n. 4 of 1999	Authorizes PB for wildfire prevention
Lombardy	Regional forest regulations n. 5/2007	PB can be authorized under exceptional circumstances
Piedmont	Regional Law n. 21 of 2013	Authorizes PB for wildfire prevention and land management
Tuscany	Regulation 8 August 2003, n.48/R *Modified by Decree of the President of the Regional Council of 16 March 2010, n. 32 / R* *and* *Regulation 19 February 2019, n. 11 / R*	Gives permission to perform PB

All of the aforementioned Regions grant permission to conduct PB for a number of objectives, mostly for wildfire protection and land management objectives, but also for the control of pests

and diseases and pasture regeneration. However, none of these regional regulations offer a comprehensive list of guidelines for its use.
Some Regions, although, include and better regulate PB in their regional Forest Fire Prevention Plan (AIB Plan), like Lazio, Liguria, Calabria, and Tuscany.
In Tuscany especially, PB is well regulated through its pluri-annual fire prevention campaigns, particularly in its last one (for the years 2019-2022). In Lombardy, PB is allowed as a wildfire preventive measure only under exceptional circumstances, and its AIB Plan recommends its use only on an experimental basis.

There are no laws governing or discussing PB in Sicily, Molise, Emilia Romagna, Sardinia, or Valle d'Aosta, but they do incorporate its implementation in their AIB.

In some of these regions' AIB, PB falls between the admitted actions for wildfire prevention, but the plan is limited only to authorize its use, and it delegates the responsibility to formulate its instructions to the designated authority or personnel. This is the case for Molise, Sicily, and Emilia Romagna; in the latter one's AIB, PB is even defined as a "last resort for wildfire prevention". In Sardinia, the AIB only offers a limited set of restrictions, mostly pertaining to the times of year during which PB can be carried out, and only permits PB on an experimental basis.

PB is well specified in the AIB Plan of Valle d'Aosta, which has a chapter devoted to its regulation. This chapter covers the reasons for which PB can be implemented in the area, the necessary weather conditions, and who is authorized to execute it.

In Umbria, Marche, Veneto, Trentino Alto Adige, and Friuli-Venezia Giulia, PB is not currently mentioned in any laws or the AIB Plan.

3.2 Objectives

Regardless of the varied normative framework pertinent to PB across Portugal, Spain, and Italy, every legislation, or fire management plan, states for which exact scopes PB can implemented and used. Totally, the study has found 10 predominant objectives for PB across the statutory frameworks of Portugal, the Autonomous Communities and the Regions of Italy (Figure 6).

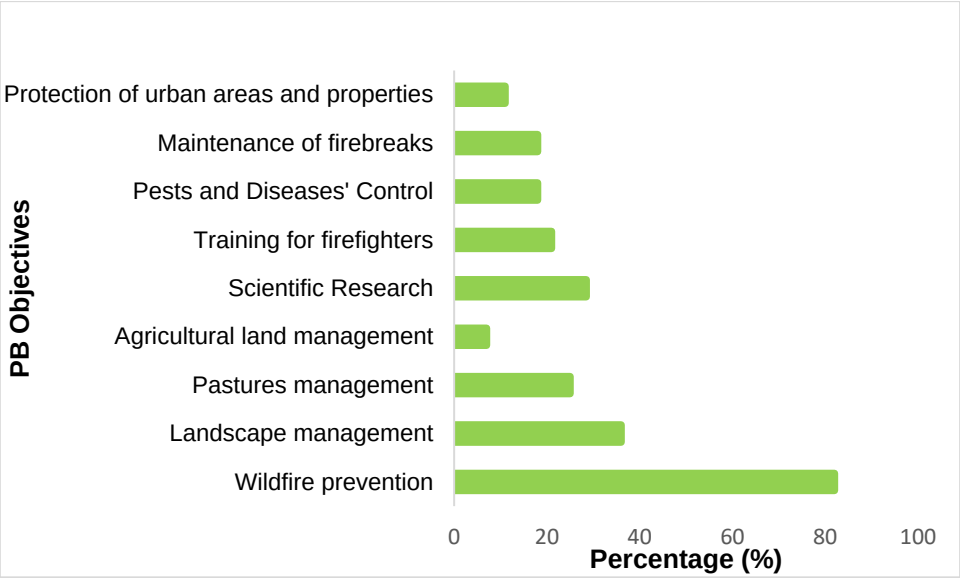

Figure 6: PB objectives in the legislative framework of Portugal, the Spanish autonomous communities, and the Italian regions.

Undoubtedly, PB is mostly employed to prevent major wildfires by lowering the fuel load. According to the legal systems of the nations and areas covered in this study, landscape management is the second main goal of PB. Landscape management in this context refers to the conservative management of the environment, which includes local fauna and flora's natural habitats, where fire plays an important ecological function.

Scientific research is the third main motive for which PB is permitted in Portugal, Spain, and Italy, with about 28,5% of the reviewed territories mentioning this purpose in their legislations. In these cases, the research looks into how PB affects the flora, how it affects fire regimes, how it works technically, and it incorporates experimental try-outs.

Although more regions employ PB for pasture management (25%) than for operations in the agricultural fields (7%), it is nonetheless commonly used to meet management goals in agro-pastoral contexts. PB is used in pasture management to burn shrubs and grasslands, to improve the quality of forage and to regenerate pastures to prevent fires of pastoral origin. In agriculture, PB serves to enhance the management of productive trees, to prepare the soil sowing by boosting the germination bed, and to control harmful pathogens in agricultural crops. This objective does not cover the burning of stubbles and stockpiles of plant materials, from both agricultural or silvicultural activities; although these are traditional agro-forestry-pastoral practices, they do not fall within the definition of PB, and they are not conducted by specialized personnel.

Less than a quarter of the Regions permit PB as a form of educational practice for their firefighters (21%). PB can be performed to train personnel involved in firefighting on the operational procedures of PB itself and to form new authorized staff; it can also be used to simulate the application of backfires and to provide the trainees with the necessary skills to control fire.

In 18% of the surveyed regions, PB is allowed for the control of pests and diseases and for the maintenance of fire protection strips. In most of the regions that allow PB to counteract the spread of pathogens, the use of fire is recommended especially when it's the only mean to eradicate the pathogen. In firebreak maintenance, PB is used to maintain a low biomass fuel load in firebreaks.

Less than 15% of the regions discussed in this study place the protection of urban, and peri-urban areas, among the goals that they aim to achieve with PB. Moreover, firebreaks can already be implemented to protect human settlements from wildfires in the wildland-urban interface.

Each country or region in this study applies PB to achieve a certain set of objectives (Annex I), except for the Community of Aragon, since its Order of 20 of February of 2015 states that the Department of Agriculture, Livestock, and Environment may encourage prescribed burning that it deems acceptable, thus without acknowledging any specific objective.

The laws of Catalonia, Campania, and Apulia provide the most extensive definitions of PB's goals and operating modalities; in fact, aside from Cantabria, these three regions are the only ones to have created policies specifically for PB regulation.

Despite controlling PB through different kinds of normative frameworks, both the Italian regions of Lazio and Piedmont and the Spanish communities of Asturias and Madrid present a long set of goals. Other areas, particularly those that only allow PB on an experimental basis, may have fewer objectives (e.g., Extremadura, Sardinia, Sicily, Murcia, Abruzzo, Castilla-La Mancha, Castilla y Leon, and the Balearic Islands). The goal of landscape management via PB is a broad term that can encompass a variety of environmental aspects, such as the preservation of wildlife habitat, the regrowth of specific plant species, the upkeep of ecosystems that are prone to fire, etc.; thus, this term can include the accomplishment of multiple goals at once.

Due to the geographical and legislative diversity of the Italian and Spanish Regions, and other locally significant elements, the arrangement of PB objectives in Spain and Italy is very ad hoc

(e.g., the topography, the land use cover, the environment type, etc.). Despite geographical variations, the primary justification for PB in the two countries is the avoidance of forest fires, combined with landscape and pasture management.

3.3 Guidelines for PB

Considering the variations in terrain, environmental circumstances, and weather conditions, the operational modalities for the implementation of PB vary throughout the three countries and their regions. Not all the fire management plans and statutes here evaluated include detailed guidelines and technical directives for applying PB.

Although there are some significant regional and national disparities, Portugal, Spain, and Italy have standardized some parts of PB application and made them common laws.

3.3.1 PB Plan and Authorization

Under no circumstances may PB occur without the competent local authority's consent. The three nations are all subject to this rue. To obtain an approval, certain procedures must be followed. The technical project, which serves to specifically outline the burn's operational characteristics and its objectives, is the crucial document when applying for a permit to apply PB in any nation. To be valid, the project must obligatorily contain a broad array of detailed information about the PB. Although the exact information requested can slightly vary according to each territory, all technical projects for PB follow a patterned scheme, with a basic set of information (Figure 7).

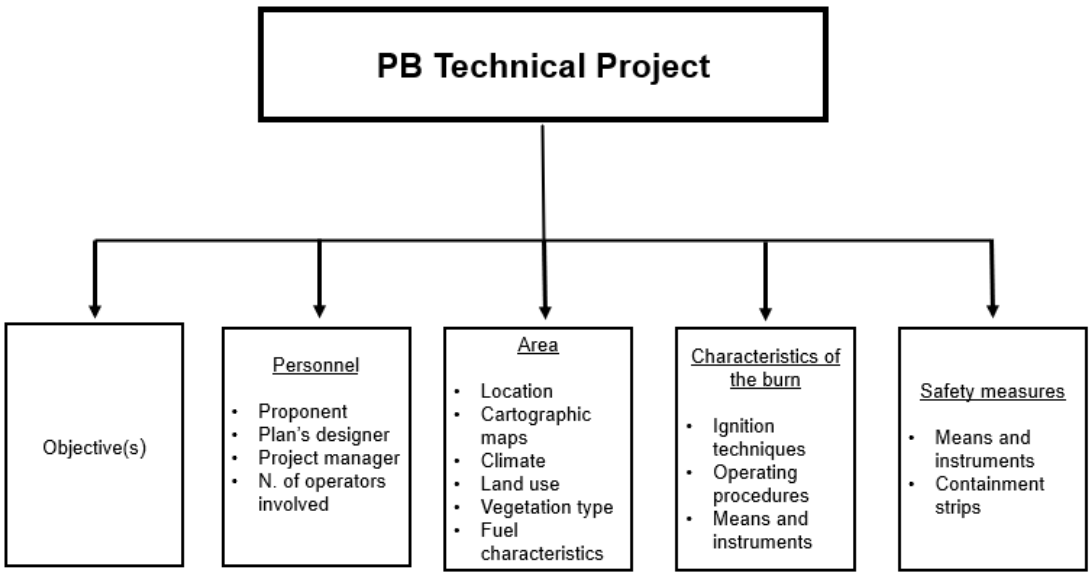

Figure 7: Standardized structure of a PB technical project.

Undoubtedly, the following diagram does not accurately depict the PB technical project each for any single region. In comparison to the PB Plan structure shown in Figure 7, only the regulatory frameworks of Portugal, Catalonia, Campania, Apulia, and Lazio give more detail.

In Catalonia, Campania, Apulia, and Lazio, the document obligates to include a section known as the “environmental window”; this term refers to the range of environmental conditions within which PB can be operated (e.g., the minimum and maximum temperature allowed for the burn to take place). The width of the window proposed in these technical papers must be considered as a reference for operating safely and achieving the burn objectives.

In Portugal, the technical plans include all the thematic areas mentioned in Figure 7, but the information regarding the area that is destined to the burn are far more detailed. The intervention area needs to be conveniently mapped out and thoroughly characterized; in addition to the information described in Figure 7, the data must contain statistics on the area’s fire history and display the location of infrastructures of defence against forest fires.

Normally, requests for an authorization to apply a PB are addressed to the competent authority that regulates all forestry-related activities. In Portugal this authority is the Municipal Commission for Forest Defence, in each Autonomous Community of Spain the correspondent competent departments listed in Table 1, and in Italy the authorization is granted by the competent structure of the Regional Council. However, in Catalonia, the authorizing entity varies depending on who specifically sends the requests to carry out a PB. Usually, PBs must be authorized by the person in charge of the General Directorate of Natural Environment; If the request is made by a private landowner, the General Directorate of Emergencies and Civil Security of the Department of the Interior of the Generalitat of Catalonia shall formulate an agreement.

3.3.2 Burn season

Another element that unites the regulations on PB in Portugal, Spain, and Italy is the need that PB activities typically only take place during a specific burn season, or the specific time of year when the meteorological circumstances make PB use safer and the risk of a wildfire spreading less likely.

Because of the various weather circumstances, each area designates some seasons as having a higher or lower danger of forest fires. This risk is typically categorized as "low," "moderate," "high," and "very high”. These times are essential for the operation of PB because it can only be used when specific weather conditions are satisfied. These periods are announced in Portugal, Spain, and Italy either through laws governing the management of forest fires or by specialized communications, like bulletins, that are issued anytime the risk of

wildfire changes. In the vast majority, the PB is only allowed during precise timespans (Table 8).

Table 8: Burn season for PB operations in Portugal, Spain, and Italy.

Country/Region	Burn season	Declared by
Portugal	Low, moderate and high wildfire risk	Bulletin
Asturias	15 October-15 April	Resolution of 5 of March 2018
Balearic Islands	16 October-30 April	Decree-law 125/2007 of 5 of October
Castilla y Leon	Low risk of wildfire	Bulletin
Extremadura	Low risk of wildfire *16 October-22 May (2021/2022)*	Annual Order
Galicia	Low and moderate risk of wildfire	Law 3/2007
Murcia	01 October-31 May	Order of 24 of May 2010
Apulia	Low and moderate risk of wildfire	Bulletin
Campania	October-April October-March *(For agro-pastoral purposes)*	Executive degree of 22 December 2020, n. 341
Calabria	All year long	AIB Plan
Lazio	Low risk of wildfire	AIB Plan
Sardinia	All year long	AIB Plan
Valle d'Aosta	Late autumn-late winter	AIB Plan

The burn season normally lasts from October to April, and regional orders clearly dictate when PB may occur.

The dates of the burn season are announced in Extremadura each year along with an annual order that specifies the high risk and low risk wildfire seasons. A low-risk season was proclaimed between October 16 and May 22, while the high-risk season began on May 23rd, according to the Orders that governed such seasons for the fire prevention campaigns of 2021–2022.

Although the time window can be calculated based on the biological traits of the significant animal and plant species that are present in the habitat, there is no set time range for PB for land management and conservation purposes in Campania.

In Catalonia, PB is can be applied throughout the whole year, regardless of the risk index for forest fires. Nonetheless, the seasons with the most frequent PBs are winter and the end of summer/beginning of autumn, depending on the type of burn and its objectives. During winter, herbs and bushes are in a state of vegetative rest, meaning that there is no important

physiological activity, due to the low temperatures; in these conditions, the aerial parts of herbs and bushes are burned and the natural response of all those plants that sprout from the roots is stimulated. PBs are carried out throughout the end of summer and autumn to simulate the natural fire regimes and to favour the germination of disseminating plants over sprouting plants, which in this period have a more difficult time activating the response. As a result, in the medium-term future, grass will predominate ahead of the scrub and this type of forest structure favours more resilience to forest fires.

PB is only permitted in exceptional circumstances in Castilla-La Mancha, Castilla y Leon, and Navarra throughout the entire year, even during the times of year when wildfires are most likely to occur. These exceptional circumstances must be documented in technical reports when applying for the authorization from the relevant authority. The burn seasons are not specified in the Communities of Cantabria and Madrid, and in the legislation of Aragon.

Only Campania, Apulia, Lazio, Sardinia, and Valle d'Aosta have explicitly declared the burn season in their regional legislation or AIB Plans in Italy. The AIB Plan of Liguria does not specify the specific months when PB use is allowed; rather, it states that PB activities are permissible whenever the air temperature ranges from 0°C to 10°C.
In Tuscany, neither the regional statutes, nor the AIB Plan, define the burn season. However, this year the regional government has prohibited, with a general character, the use of fire in forested landscapes between the 1st of July and the 31st of August. There is no suitable season mentioned in the AIB Plans for Abruzzo, Emilia Romagna, Piemonte, Sicilia, and Valle d'Aosta. Precise dates are set aside for each burn in these places because PB is still mostly used for experimental trials and is not a frequent or routine procedure.

3.3.3 Operational Procedures and Limitations

In general terms, the specific instructions for PB operations are not pointedly and extensively indicated in the national and regional legislations. In fact, the practical directives are mostly specified in the technical proposals, with the approval of specialized technicians, or other professional figures. Still, there are legislative regulations that articulate the operational procedures for PB on a generic basis, and others that provide more specific norms.

All of the PB legal frameworks that have been studied adhere to a set of standard operating procedures. All PBs are required to comply with the requirements outlined in the technical project plan. This means that fires may only take place during the designated dates and times, under the environmental conditions listed in the permitted environmental window, with the approved vegetation only, and that the necessary safety precautions must be taken.

Authorized employees or designated technicians must engage in the burn, and the personnel present during the burn must match the one mentioned in the plan.

All forms of fire use in forest or agricultural area, not just PB, are covered by more broad criteria for the implementation of PB in various Spanish autonomous communities (Table 9).

Table 9: Operational conditions stated in the PB policies of Asturias, Extremadura, Cantabria, and Madrid.

Burn season	Autonomous community	Conditions
15 October-15 April	Asturias	Not before sunrise, and until 2h before sunset Must have passed at least 3yrs from the last burn/fire 2m Firebreak No more than 10ha can be burnt
Low fire risk season	Extremadura	Must have passed at least 5yrs from the last burn/fire No more than 10ha can be burnt
N/A	Cantabria	Max. wind speed 4 (Beaufourt scale) 5m firebreak
	Madrid	No burns next to highways No wind blowing towards highways Must have passed at least 5yrs from the last burn/fire No more than 2ha can be burnt 1m Firebreak (changeable)

The communities mentioned in Table 9 are the only ones in Spain that provide some range of norms for the execution of PB in their statutes. In addition, the INFOMA of Madrid also describe the technique that are allowed for the ignition of PB, including backing fire, headline fire, flank and strip line fire, and spot fire.

Similar circumstances can be observed in Italy, where only a few regions have an AIB Plan or legislations that control the technical steps for PB in greater depth, while PB is typically only done for experimental purposes in most regions. The only documents that specify the guidelines for PB are the regional statutes of Apulia and Campania and the AIB Plans of Liguria and Valle d'Aosta. (Table 10).

Table 10: Operational conditions and requirements for PB in Valle d'Aosta, Liguria, and Apulia.

Burn Season	Region	Conditions for PB
Late autumn-Late winter	Valle d'Aosta	Vegetative rest Flame front intensity: 330-420 KW/m Flame height: 1m Slope: 0-20% Air humidity: 30-50% Air temperature: -6 – 10 ˚C Dead fuel humidity: 15-21% Wind speed: 3-15 km/h
N/A	Liguria	Vegetative rest Flame front intensity 120 kcal/m-1s-1 Flame height: 1.5m Slope: 0-20% Air humidity: 30-50% Air temperature: 0-10˚C Dead fuel humidity: 7-20% Wind speed: 3-10 km/h
	Campania	Air humidity: >40% Wind speed: 0-15 km/h^{-1} Fuel humidity: < 15 (DCM) Dead fuel humidity: 75-95 (FFMC)
	Apulia	No steep slopes No strong winds No water stress for the vegetation

It is evident that the operational conditions listed in Table 10 are far more technical than the ones in Table 9.

The humidity levels for the fuels indicated in the row of Campania, refer to the Duff Moisture Code (DMC) and the Fine Fuel Moisture Code (FFMC). These two variables are indexes of fuel moisture content, and two of the three fuel moisture content elements of the Canadian Forest Fire Weather Index (FWI) system. The European Forest Fire Information System (EFFIS) publishes these values for the region of Campania on a daily basis. The Executive Decree of Campania lists the specific technical requirements for each objective and management area of PB (Annex II, Annex III, Annex IV, Annex V).

3.4 Authorized personnel and training programs

3.4.1 Authorized personnel

In all the three countries' regulatory frameworks it is clearly expressed that PB can only be performed by designated staff. Yet, the definition of authorized is not homogenous across Portugal and the Spanish and Italian regions; many regulations, in fact, outline various bodies and authorities involved in PB operations (Table 11).

Table 11: Authorized and involved staff in PB operations as stated in the normative frameworks of Portugal, Spain, and Italy.

Country/Region	Personnel involved
Portugal	Fire fighters ANEPC PB Technicians
Asturias	Director Technician/ Forest firefighters
Catalonia	Forest firefighters of Generalitat de Catalunya
Cantabria	Professional teams
Castilla-La Mancha	Ministry of Environment and Rural Development
Galicia	Technical personnel authorized for PB
Madrid	Technical staff of the General Directorate responsible for civil protection
Navarra	Qualified staff Supervision of Forest Service of the Department of Rural Development, Environment and Local Administration
Italy	Forest firefighters

In Portugal, PB is conducted by technicians specifically accredited in PB by the ICNF, having passed the training courses run by certified companies or educational institutions. The local fire brigade and the command structure of the ANEPC also participate in PB activities, to ensure its safe execution and that the conditions initially established for its realization are preserved.

The Decree-law of Catalonia instructs that the material execution of PBs is entrusted to the Fire Brigade of the Generalitat of Catalonia, the regional government. The Catalan Fire Brigade has a division called Group of Support to Forest Actions (GRAF), which oversees PB in the Autonomous Community, that is specifically created for battling forest fires. Among the appointed firefighters to execute it, one must be assigned to act as the person in charge of the burn, to watch over the security of the staff and to direct the operations; this figure must have passed the specific training in leading and executing PB given by the Institute for Public Safety of Catalonia (ISPC), in addition to the ones already delivered to general PB staff.

In Asturias, PB is operated by firefighters under the supervision of either a Technical Director or an agent of the regional Forestry Corp.

Both the communities of Madrid, Castilla La-Mancha's authorized staff are firefighters' personnel designated by the competent regional authorities, without any reference to what kind of background and knowledge they must own.

In Galicia, Navarra, and Cantabria there is no clear definition of the parameters that define authorized or qualified staff for the execution of PB. In addition to the qualified staff, Navarra mandates that all PBs must be supervised by the community's Forest Service.

Fire fighters specialized in forest fires are the ones in charge of applying PB over all of Italy. Only Tuscany, Campania, and Apulia require that the fire fighters who work in PB operations complete particular training courses.

3.4.2 Training Programs

Throughout this study, different disciplinary approaches for PB were found for Portugal, Spain, and Italy. The only territories that have implemented specific programs to conduct PB are Portugal, Catalonia, Tuscany, and Campania.

Portugal is the only nation in this study to have, as of this writing, created national regulations for the training of technicians qualified for PB, as evidenced by Order No. 7510/2014, dated June 9, 2014. The training program is accredited by the ICNF, and those who complete it receive the official certification as PB technicians. The title is valid for five years, and the ICNF may decide to renew it if the technician has engaged in at least 150 hours of PB operations and has complied with all applicable laws and regulations during that time. The trainers who deliver the course's modules and educational exercises must be listed in the National Registry of Trainers in PB; to qualify as a PB trainer, the instructor must be a certified PB technician who has participated in PBs for at least 300 hours and who has written a PB plan within the previous five years.

The Portuguese PB Training Course delivers numerous different modules with a heavy workload to its learners, giving them a wide range of PB management skills and expertise. (Table 12).

Table 12: PB Training Course administered in Portugal

Training Unit	Workload
Fire use framework	2h
Fire behaviour	5h
Impacts of fire	7h
Operational implementation of PB	7h
Use of decision support tools	7h
Preparation of the PB Plan and the Burning Operational Plan	21h
Planning, execution and evaluation of PB in shrub and tree formations	70h
Total of hours:	119h

The Portuguese course's approach encompasses more practical than theorical workload, with most of the activities concentrated in the processes involved in the preparation and operation of a PB.

In Catalonia, the ISPC formulates the material content for PB training courses. Unlike Portugal, the training program concerns technical fire, and not just PB; therefore, the training units comprise the topic of backfire as well. The program divides into two categories, depending on who is to enrol.

The first training is designed for emergency workers (forest firefighters, volunteers, etc.) who want or need to be involved in PB teams and disseminates the standard knowledge and experience for using PB as a land management tool. The second course is intended to be offered to fire fighters who command PB teams and operations; as a result, it has a somewhat different structure. These fire fighters require a different set of PB skills, particularly for the planning and implementation of PBs. Both courses involve 50 hours of work and have identical basic training modules (Table 13).

Table 13: Technical fire courses in Catalonia

Course	Training units	Workload
Basic course in PB	Piroecology Meteorology PB Plan. PB Preparation PB Safety PB patterns. PB Evaluation Transmissions Back fire	50h
Advanced course in PB	Piroecology Advanced Meteorology Planification and execution of PB PB Safety (Head of Safety) PB Execution (Head of Ignition) Command of the burn (Head of the Burn) PB Evaluation Transmission Back fire	

The advanced course in PB ensures that its trainees are provided with the essential qualifications and dexterities to ensure that each PB is coordinated and executed adequately, and that both the safety of the staff and the area are assured. To enrol in such course, it is first necessary to pass the basic course in PB.

In the Italian peninsula, there is no legislation, nor fire management plan, that discusses the terms for the training of PB personnel. Only in Tuscany, the regional Forest Fire Training Centre has hosted PB some training programs. The regional department coordinates the PB

training programs with the cooperation company “DREAm Italia”, specialized in sustainable landscape management and firefighting services.

Campania lacks a training program that is governed by the laws governing PB, but it has partnered with the Southern Apennine Observatory Consortium, based on the campus of the University of Salerno, to create a training program on the planning, managing, and carrying out of PB interventions. The course usually takes place within a month, and is composed of 60 hours in total, distributed in 34 hours through webinars, 21 hours of practice in the field, and the remaining 5 hours in presential seminars. The objective of this course is to train qualified experts in the design and management of PB sites in the Campania Region, with extensive knowledge from relevant experts in Italy and with field work. The program comprises 39 training units, that mainly focus on fire behaviour, PB simulations and international case studies.

There is no legislative definition of an adequate training program in Apulia, despite the regional law mandating only individuals qualified in PB to conduct such interventions, and the Regional Council has not yet launched any initiatives.

3.5 PB in Agro-pastoral activities

The legislative representation of agro-pastoral interests in the legal PB frameworks of Portugal, Spain, and Italy demonstrates the importance of traditional burning practices in Southern Europe.

Figure 6 demonstrates that while the management of agricultural crops by PB is restricted to a few regions, many of the laws analysed in this study list the control of pastures as one of their justifications for its application. The use of fire for the burning of heaped stubbles and stockpiles of plant materials from both agricultural and silvicultural activities is covered in several of the laws that were analysed in this study.; however, these activities, even though they are important traditional agro-forestry-pastoral practices in fire use, do not comply with the definition of and the purposes of PB discussed in this study.

Since the use of fire for pasture management represents a form of PB, in most of the reviewed territories its execution is regulated with the same norms for general PB operations. However, only in Portugal and Cantabria pasture renovations with PB have their own technical standards and involve a distinct group of authorized personnel.

Extensive Burning (EB) (or “queimada”, in Portuguese) is the term used by Portuguese authorities to further distinguish this sort of burning from other PB measures. This denomination indicates the burning of rangelands for pasture regeneration. The execution of EB does not require to be operated by technicians officially accredited in PB; in this case landowners, farmers, etc., might carry out the burn themselves. However, the EB needs to be

conducted under the supervision of a technician certified in PB, or in their absence, by a group of firemen or forest firefighters, or by members of the national corps of forest agents, the special civil protection force, or the special protection and rescue unit.

Operationally, EB is more straightforward than PB overall (Figure 8).

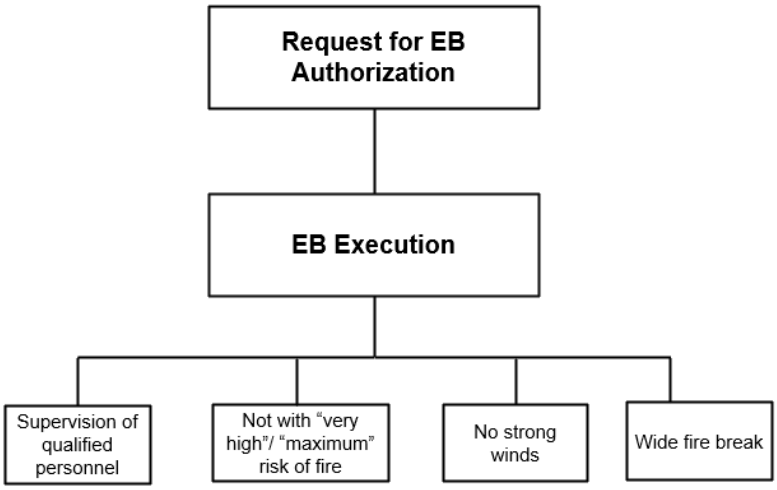

Figure 8: Scheme for the procedure of EB operations in Portugal.

The person in charge of the burn must first submit an authorization request via an online platform provided by the ICNF to the competent municipality. The type of burn, the intended date, the local weather conditions, and the wildfire risk at that time must all be specified in the request. The authorization request must include a map of the surrounding area. In contrast to PB, an EB authorisation does not call for a technical plan.

The process can move on with the execution of the EB if the request is approved. A qualified team or staff must supervise the operation, and a wide fire break that is at least twice as tall as the vegetation to be burned is needed. Only when the risk of forest fire presented by the ICNF is low, moderate, or high the EB can occur.

The Cantabrian Order MED/3/2021 of 9 of March has implemented a similar procedure for PB in the agro-pastoral sector.

This statute categorizes PB into two different categories: "Simplified Burn" and "Standard Burning." The first term refers to controlled burns low degree of complexity and can be executed by the interested party with their means. This includes the burning of rangelands and agricultural crops for their enhancement. The Standard Burn is used to describe burns that are more complex and whose execution necessitates the involvement of expert teams as well as detailed planning and supervision.

The interested party and a group of individuals can carry out Simplified Burns directly. The participating teams consists of a Head of Burn, who is in charge of the operational and safety aspects of the burn, and a group of voluntary figures to provide support. The Head of Burn must have successfully completed a training course given by the appropriate authority (Table 14).

Table 14: Training program for Head of Simplified Burning in Cantabria.

Training Units	Workload
PB regulations and authorization. PB safety Basic meteorology applied to PB Physical environment of the burn plot Basic Fire Management Principles Tools and equipment for the execution of PB	8h

The course must have a minimum duration of 8 hours, of which 4 at least must be spent in practical activities. Although, the training program is certainly not extensive, the Act cites that the competent General Directorate is committed to promoting more technical trainings for the execution of Simplified Burns.

Similar to EB in Portugal, Simplified Burning does not require the submission of a burn plan in order to get a permit from the appropriate authorities.

4. DISCUSSION

This study has demonstrated how the regulatory environment for PB in Mediterranean Europe has an uneven, distinctive regional structure and the author(s) do see it as a negative issue.

Out of the three studied countries, only Portugal has established a well exhaustive legislative framework for the management of PB nationwide. Only the region of Catalonia in Spain has implemented a decree-law special to technical fire, leading to the creation of a wide-ranging PB network that makes it easier to record PBs, train competent employees, and share resources and information connected to PB in the region. The recent Regional Laws of Campania and Apulia in Italy are the country's first attempt to impose better and more thorough PB rules.

In the rest of the Spanish autonomous communities and in Italy the regulatory frameworks of PB are still limited, and in some cases even inadequate. This fragmentation in the regularization of PB has resulted into an insufficient application of the practice across most of the study areas (Fernandes et al., 2022).

Different factors have contributed to the development of PB policies and regulation between Portugal, Spain and Italy. The history of PB application in the macro-region has certainly played a part in its inclusion in the national and regional legislations of each country.

PB was first introduced in Italy, Portugal, and Spain in the 1970s with experimental efforts to study its effects and efficiency in the context of European Mediterranean ecosystems (Ascoli & Bovio, 2013; Fernandes, 2018).

In the Iberian Peninsula, PB sparked the immediate interest of the scientific community, especially in Portugal; the Portuguese forestry authorities, in fact, immediately adjusted the application of PB to its pine stands, and by 1982 it already established a PB program in its North-Western divisions (Fernandes, 2018). During this time, a substantial effort of cooperation was implemented by Portuguese and foreign researches and forest managers, including the international collaboration the Tall Timber Research Station and the USDA Forest Service (Fernandes, 2018; Fernandes et al., 2022). With the increase of calamitous forest fires frequencies, PB received more inclusion with legal protection (Fernandes et al., 2022).

In Spain, instead, a different scenario occurred. Despite an initial interest, with the first PBs in eucalyptus stands of Galicia in the late 70s and international partnerships, the research efforts became sparse at a national level, due to decision making mechanisms by regional forest managers (Fernandes et al., 2022). The autonomous community of Catalonia was the first one to open the debate on fire management, which at the time almost exclusively aimed for wildfire suppression, rather than prevention, following a disastrous wildfire season between 1994 and

1998; by 1999/200, Catalonia started to develop programs to enhance PB use and to train firefighting personnel with it (Pastor et al., 2009). It is important to note one of the earliest PB experimental attempts, which took place in the Catalan province of Lleida in December 1998 and led to the treatment of roughly 200ha with PB (Molina-Terrén, 2021). This approach ultimately resulted into the present Catalan decree-law exclusively designed for the regulation of technical fire in the region, the only one of this kind so far in Spain.
The other autonomous Spanish communities have started to reevaluate their fire management means in the later years, with a general agreement that the total exclusion of fire in rural areas is only detrimental.

In the Italian peninsula, the use of PB evolved differently. The first attempts of PB in the country date back to the late 70s, and later throughout the 80s and 90s some experimental trials were carried out by the Experimental Institute of Forestry in maritime pine stands of Tuscany and for fire break maintenance in Sardinia; despite the satisfying results from these tryouts, PB did not stimulate as much scientific interest as in Spain and Portugal, and further research wasn't pursued (Ascoli and Bovio, 2013). Although PB executions are scarce in Italy, there is evidence suggesting its viability as landscape management tool in the Italian territory (Ascoli et al., 2009; Battipaglia et al., 2017; Battipaglia et al., 2016).

Indeed, this lack of scientific research has contributed to the scarce and fragmentary PB regulatory framework in Italy, since research outcomes are the among main drivers for policy making processes in forestry (Nagasaka et al., 2016) . Besides, the practice of PB, and the subsequent political regulation, has been heavily constrained in Italy due to an extended list of causes.

Ascoli and Bovio, 2013 describe the main challenges that have hindered the inclusion of PB among land management tools in Italy. One of the principal reasons why PB hasn't been much carried out in Italy is the country's adverse topographic characteristics. Italy, in fact, is covered 35,2% covered by mountains and 41,6% covered by hills, where many forests and shrublands are located, yet inaccessible. The high elevations, the slopes, and the erratic windy patterns of mountainous areas are more complicated and complex for the execution of PB. The lack of participation from private forest owners has also prevented the use of prescribed burning on a national scale. Forest management itself in Italy has been an obstacle for PB; the Italian forestry sector generally seeks to stimulate and preserve natural regeneration and uneven-age forests and stands, which causes conflicts with the use of fire.

The current fire management approach implemented in Italy also represents a major constraint for the application of PB in the country. The latest decree-law in the field of forest fires

demonstrates how the Italian forestry sector is still attempting to tackle the issue of wildfires through fire suppression, instead on emphasising the key role of fire prevention plans. The lack of a common fire prevention national plan and standardized requirements for PB use represents an additional challenge, contributed by the fact that most of the Italian regions do not clearly define the background and training criteria for PB personnel.
The Italian forestry sector urgently needs to shift this approach, and to re-integrate and manage the use of fire in its fire-prone ecosystems, especially for fuel treatment considering that each year the country experiences an afforestation rate of about 30,000 hectares per year from rural depopulation and the abandonment of agro-silvo-pastoral practices (Bovio et al., 2017).

Out of all the areas under study, Portugal and Catalonia have the greatest annual PB interventions because both have a longer history of PB application and regulation. (Fernandes et al., 2016). For example, 162ha were burnt during the 2020-2021 PB campaign in Catalonia, whilst in Tuscany only about 17ha were burnt with PB just in 2020 (Bombers de Catalunya, 2021; Tonarelli et al., 2020). Additionally, the Catalan Decree-Law has never changed since its adoption in 2005, which should show that the stringent rules are enabling PB to be an effective technique for reducing wildfire hazards, as supported by scientific data (Duane et al., 2019).

A crucial component of safe and effective PB operations and to support its implementation are the training programs for the personnel assigned to prescribed fire operations. (Molina Terrén & Colaço, 2015; Morgan et al., 2020). The shortage of qualified personnel in PB severely constraints the application of PB, and it reduces its attainability as an effective wildfire hazard reduction tool (Francos & Úbeda, 2021). Instead, having skilled staff that have been purposely trained in PB management facilitates its implementation, and it results into a higher number of PB operations and more incorporation of PB in legislations and forest fire management plans. In fact, between all the territories whose PB legislative frameworks have been reviewed in this study, the most PB operations occur in regions where specific PB training programs are regulated; hence Catalonia, Tuscany, and Campania are the regions with the most PB interventions in their respective countries, along with Portugal.
The study has highlighted how, both in Spain and in Italy, there is inconsistency in the administration and delivery of PB training programmes nationwide and a lack of development and promotion of such programs by both nation's governmental bodies.
In recent years, improvements have been noted in this regard in Italy, with the accreditation of 120 new qualified staff in PB in the region of Campania by the end of 2021 (Consorzio Osservatorio Appennino Meridionale, 2022).

The creative PB strategy used by Portugal and Cantabria PB for agro-pastoral goals further enhances the effectiveness of PB. In Mediterranean Europe, in fact, there's always been a strong conflict of interests between traditional burning and PB (Ascoli and Bovio, 2013; Coughlan, 2014; P. M. Fernandes et al., 2013). Engaging rural populations in the landscape management with the support and supervision of experts will undoubtedly ease the conflict and may ultimately result in a resolution for both parties. Moreover, this strategy might help to lessen wildfires of pastoral origins, which are among the major sources of ignition in the Mediterranean Basin. (Ruiz-Mirazo et al., 2012).

In both Spain and Italy there is no unitary framework of regulation for PB. The legislations that regulate PB are varied and there are pronounced differences among the Regions. More legislations provide legal basis for PB in Spain than in Italy, where PB is mainly addressed through regional fire prevention programs. Although, most of the Spanish Autonomous Communities regulate provide more legal coverage for the use of fire in the agro-pastoral context, rather than as a resource for the management and conservation of forested areas.

Even in the Communities in which PB is not regulated (Andalucía, La Rioja, Valencia, Basque Country, and Canary Islands) there is evidence of the suitability of PB as wildfire hazard management tool and as a beneficial practice for their environments (Hueso-González et al., 2018; Vega et al., 2000). For these Regions, there has been a slight progress in the regulation of PB; in the Community of Valencia, an Order is awaiting approval that may finally control PB use within the Valencian territories.
In the Canary Islands, PB operations actually do take place, and it is applied for wildfire prevention purposes, even with specialized teams (Lazaro & Montiel, 2010). In Gran Canary Island, the employment of PB (2002-2005), has proven to be particularly effective for landscape management, the protection of sensitive areas, and an important tool for wildfire prevention efforts whilst preserving natural processes (Molina Terrén et al., 2005)
however, no regulatory framework that administers PB in the archipelago could be found.

This applies as well for regions that do not have complex legislative regulations for PB. For example, in the urban-forest interface of the city of Puertollano, Castilla-La Mancha, PB has become a routinary practice for the protection of urban area from wildfires, with a PB intervention every year (Junta de Comunidades de Castilla-LaMancha, 2015). The urban structure, in fact, is situated in a zone with a high risk of forest fire, due to the extensive presence of road, power lines, the high population density, and a long history of forest fires. Since the area has experienced numerous forest fires, most of which have been brought on

by nearby highways, PBs are applied in strategic points to reduce the fuel load next to the roadways and also to create fire breaks along the roads.

Recent developments in the legislative frameworks of the Spanish Autonomous communities and the Italian regions are indicating that PB management is being addressed with a new outlook in both countries and that fire is being more recognized as an integrated element of the Mediterranean ecosystems.

The implementation of specific PB policies in Apulia and Campania, respectively in 2021 and 2016/2020, marks the awaited recognition of the important ecological role of fire by the Italian forestry sector. Suffice it to say that the Apulian law was approved unanimously by the Regional Council (Consiglio Regionale della Puglia, 2021).
The legislations of Campania clearly define the design elements for PB operations in the Region, which are scarcely delineated in the normative frameworks for PB in the rest of the Italian regions (Bovio & Ascoli, 2012).
The latest order in Cantabria as well indicates an ever-greater legal coverage of PB in Spain. In fact, a specific order for the regulation of PB was deemed an urgent concern in the community's "Strategic Plan for the Prevention and Fight against Forest Fires" (PEPLIF) for the campaign of 2017–2020. The Order itself describes PB as a fine opportunity to support collaboration, and co-responsibility between the different actors involved in the use and management of forested areas in Cantabria.
Additionally, the capable Cantabrian General Directorate pledges, via the implementation of numerous projects, to advance the use of fire for land management. The authority's suggested solutions include PB basic training sessions and a burns registry with key details for each burn, such as the burn's goals, location, digital map, plan, and post-burn evaluation. To enable a public and open process for PB, this goal aims to create a comprehensive system and network for PB in Cantabria.
All these Laws, meanwhile, are still very new, so it's too soon to determine whether they have actually made a substantial impact on improving PB procedures in the Regions and increasing the number of operations.

6. CONCLUSIONS

This study has evidenced the marked difference in the legislative approach towards PB as a landscape management tool between Portugal, Spain and Italy.

Portugal is the best illustration of a comprehensive legislative framework for PB, whereas in Italy and Spain only a few regions have adopted this legislative strategy. In the regional statutory frameworks of Spain and Italy, frequently, the technical guidelines for PB are not listed. The most comprehensive policies regulate PB in great detail (e.g., Catalonia, Campania and Apulia) while some just address it, while yet others still discuss it only on a marginal level.

Wildfire prevention is certainly the main rationale for most of the reviewed territories to incorporate PB in their fire management frameworks. In particular, its use for landscape and rangeland management and scientific research is receiving more interest.

Due to geographical variations in geography and temperature, PB application restrictions and operational standards range across Southern Europe. The study has shown that it is still possible to have a set of fundamental guidelines at the national level while still addressing the specifics of each prescribed burning in light of the environmental circumstances.

In most cases, the figures in charge of designing and executing PB operations are not well specified in the legislations. Through their statutory frameworks, only Portugal and Catalonia have developed effective training programs for individuals involved in PB.

The laws of Portugal and Cantabria demonstrate the possibility to ensure a safe implementation of PB in agricultural and pastoral settings by establishing a different procedure for these kinds of burns and establishing a partnership between the institutions and the agro-pastoral communities in the management of the landscape.

This study works to highlight the need of a general framework for PB in each Southern European State, by describing and comparing the norms currently in place at an international scale, and by highlighting the areas that represent a gap, such has the lack of a unitary statute for the regulation of PB in Italy and Spain and of the implementation of a standard professional figure for PB interventions.

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ANNEX I. Objectives of PB in the legislative frameworks of Portugal, the Spanish autonomous communities, and the Italian regions.

Country/Region	Objectives of PB
Portugal	*Wildfire prevention* *Landscape management*
Asturias	*Wildfire prevention* *Landscape management* *Agro-pastoral management* *Firebreak maintenance* *Protection of urban areas*
Balearic Islands	*Wildfire prevention*
Cantabria	*Wildfire prevention* *Landscape management* *Agro-pastoral management*
Castilla-La Mancha	*Wildfire prevention* *Training for firefighters* *Scientific Research*
Castilla y Leon	*Wildfire prevention* *Landscape management* *Pests and diseases' control*
Catalonia	*Wildfire prevention* *Landscape management* *Training for firefighters* *Scientific Research* *Agro-pastoral management* *Protection of urban areas*
Extremadura	*Wildfire prevention* *Scientific Research*
Galicia	*Wildfire prevention* *Agro-pastoral management*
Murcia	*Wildfire prevention*
Madrid	*Wildfire prevention* *Landscape management* *Pests and diseases- control* *Agro-pastoral management* *Firebreak maintenance* *Protection of urban areas*
Navarra	*Wildfire prevention* *Training for firefighters* *Control of pests and diseases*
Abruzzo	*Wildfire prevention*
Apulia	*Wildfire prevention* *Landscape management* *Research* *Pasture management* *Firebreak maintenance*
Basilicata	*Wildfire prevention* *Firebreak maintenance*
Campania	*Wildfire prevention* *Landscape management* *Training for forest fighters*

	Scientific Research *Pasture management* *Firebreak maintenance*
Calabria	*Wildfire prevention* *Landscape management* *Research* *Pasture management* *Firebreak maintenance*
Emilia Romagna	*Wildfire prevention* *Pests and diseases control*
Lazio	*Wildfire prevention* *Landscape management* *Training for firefighters* *Research* *Firebreak maintenace*
Liguria	*Wildfire prevention*
Lombardy	*Research*
Piedmont	*Wildfire prevention* *Landscape management* *Research* *Pasture management* *Firebreak maintenance*
Tuscany	*Wildfire prevention* *Landscape management* *Agro-pastoral management*
Sardinia	*Research*
Sicily	*Wildfire prevention*
Valle d'Aosta	*Wildfire prevention* *Firebreak maintenance*

ANNEX II. Prescriptions for PB for the maintenance of firebreaks in herbaceous and low shrub formations in Campania, Italy

From Executive degree of 22 December 2020, n. 341 of the Regional Council of Campania (Italian: Decreto Dirigenziale del 22 Dicembre 2020, n. 341, Giunta Regionale della Campania).

Table 1.B - Fire prevention: stands of conifers and broad-leaved trees (art.2, par.2a)			
Technical requirements	**Desired values (min. – max.)**	**Behaviour of PB**	**Desired values (min. – max.)**
Operating season	October- April	Flame length (m)	0.1-1.5
Air temperature (˚C)	2-18	Propagation speed (m/min)	0.1-2
Relative humidity (%)	40 – 70	**Combustible humidity**	**Desired values (min. – max)**
Days without wind (n°)	2-15		
Wind speed (km/h)	1 – 8	FFMC	75 – 90
Wind direction (°N)	0 – 360	DMC	< 15
Ignition techniques ☐ linear bracing and slope ; ☐ points in favor of wind and slope ☐ parallel stripes in favor of wind and slope ☐ lines along the maximum slope ☐ perimeter ignition			

ANNEX III. Prescriptions for PB operations in stands of conifers and broad-leaved trees in Campania, Italy

From Executive degree of 22 December 2020, n. 341 of the Regional Council of Campania (Italian: Decreto Dirigenziale del 22 Dicembre 2020, n. 341, Giunta Regionale della Campania)

Table 1.A - Fire prevention: fire protection avenues in herbaceous and low shrub formations (art.2, par.2a)			
Technical requirements	**Desired values (min. – max.)**	**Behaviour of PB**	**Desired values (min. – max.)**
Operating season	October- March	Flame length (m)	1 – 4
Air temperature (˚C)	-2 – 22	Propagation speed (m/min)	1 – 5
Relative humidity (%)	40 – 70	**Combustible humidity**	**Desired values (min. – max)**
Days without wind (n°)	2-15		
Wind speed (km/h)	1 – 15	FFMC	75 – 90
Wind direction (°N)	0 – 360	DMC	< 15
Tecniche di accensione ☐ lineare controvento e pendenza; ☐ punti a favore di vento e pendenza ☐ strisce parallele a favore di vento e pendenza ☐ linee lungo la massima pendenza ☐ accensione perimetrale			

ANNEX IV. Prescriptions for PB operations for habitat and landscape conservation management in Campania, Italy

From Executive degree of 22 December 2020, n. 341 of the Regional Council of Campania (Italian: Decreto Dirigenziale del 22 Dicembre 2020, n. 341, Giunta Regionale della Campania).

<table>
<tr><th colspan="4">Table 1.C – Habitat and landscape conservation management (art.2, co. 2b)</th></tr>
<tr><td>Technical requirements</td><td>Desired values (min. – max.)</td><td>Behaviour of PB</td><td>Desired values (min. – max.)</td></tr>
<tr><td>Operating season</td><td>To be defined based on the ecological traits of the animal and plant species of interest present in the habitat</td><td>Flame length (m)</td><td>0.1-4</td></tr>
<tr><td>Air temperature (˚C)</td><td>2-18</td><td>Propagation speed (m/min)</td><td>0.1-5</td></tr>
<tr><td>Relative humidity (%)</td><td>40 – 70</td><td rowspan="2">Combustible humidity</td><td>Desired values (min. – max)</td></tr>
<tr><td>Days without wind (n°)</td><td>2-15</td><td></td></tr>
<tr><td>Wind speed (km/h)</td><td>1 – 8</td><td>FFMC</td><td>75 – 90</td></tr>
<tr><td>Wind direction (°N)</td><td>0 – 360</td><td>DMC</td><td>< 15</td></tr>
<tr><td colspan="4">Ignition techniques
☐ linear bracing and slope; ☐ points in favor of wind and slope ☐ parallel stripes in favor of wind and slope ☐ lines along the maximum slope ☐ perimeter ignition</td></tr>
</table>

ANNEX V. Prescriptions for PB operations in agro-forestry-pastoral activities in Campania, Italy

From Executive degree of 22 December 2020, n. 341 of the Regional Council of Campania (Italian: Decreto Dirigenziale del 22 Dicembre 2020, n. 341, Giunta Regionale della Campania).

Table 1.D – Agro-forestry pastoral activities (art.2, co. 2b)			
Technical requirements	**Desired values (min. – max.)**	**Behaviour of PB**	**Desired values (min. – max.)**
Operating season	Ottobre-Marzo	Flame length (m)	0.1-1
Air temperature (˚C)	2-18	Propagation speed (m/min)	0.1-2
Relative humidity (%)	40 – 70	**Combustible humidity**	**Desired values (min. – max)**
Days without wind (n°)	2-15		
Wind speed (km/h)	1 – 6	FFMC	75 – 90
Wind direction (°N)	0 – 360	DMC	< 15
Ignition techniques ☐ linear bracing and slope; ☐ points in favor of wind and slope ☐ parallel stripes in favor of wind and slope ☐ lines along the maximum slope ☐ perimeter ignition			