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Carbon and Biodiversity Policies: Opportunities for Synergies in the Mediterranean Basin

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Abstract

Wildfires are a concern in many European countries, and they might occur more frequently given climate change. Carbon sequestration is an ecosystem service provided by forests that is affected by fires and is neglected in traditional markets. Recently, the European Union (EU) has created environmental policies that address climate change, wildfires, and biodiversity conservation through payment for ecosystem services schemes. This study aims to estimate the monetary carbon savings of avoiding wildfires in five Mediterranean countries using historical wildfire emissions data and the auction prices in the EU Carbon Market. Portugal is further studied since the country has a new ecosystem services payment policy. The results indicate that, by avoiding fires, the countries could have annual benefits in the order of millions of euros. For Portugal, the value of the policy incentive is inferior to the value of the carbon sequestration service provided by avoiding fires and could be reexamined.

Author Keywords. Wildfire, Emissions, Forest Management, Carbon Sequestration, Ecosystem Services.

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1. Introduction

The European Commission recognizes that the biodiversity crisis and the climate crisis are intrinsically connected. Climate change leads to the devastation of the natural environment through more extreme climatic events, such as wildfires, while the loss and unsustainable use of natural resources are promoters of climate change (European Commission 2020a).

In Mediterranean Europe, despite other environmental and public health concerns, climate change is mainly noticed by an increase in wildfire risk, an extension of the fire season, and an intensification of extreme events throughout the season, conceivably leading to more severe and frequent occurrences (Raftoyannis et al. 2014; Ruffault et al. 2020).

The loss of forest cover caused by wildfires impacts many of its ecosystem services, including aesthetic and recreational opportunities, the provision of raw materials, and climate regulation, namely through carbon sequestration. Forests are considered the most efficient carbon sequestration systems amongst terrestrial ecosystems, as the many public services they offer greatly contribute to reducing CO_2 in the atmosphere (Liu and Wu 2017).

In this sense, meticulously designed policies, such as payments for ecosystem services (PES) schemes, can stimulate potential ecosystem service suppliers (landowners, in the case of forests) through the use of payments for action, access, or maintenance of a service (Guerry et al. 2015). Furthermore, in the case of forest ecosystems, it has been suggested that a tax on fossil fuels can support their restoration, which in turn, can help curb climate change (Barbier et al. 2020).

In this context, all the European Union (EU) Member States are engaged in mapping and assessing the state and trends of their ecosystems and their services, which is done to help in informing policies and decisions affecting the environment (European Commission 2021).

Portugal, a country that is considered a characteristic representative of the Mediterranean region for forest-management interventions (Oliveira et al. 2017), has recently developed environmental policies aligned with the European guidelines. The Resolution of the Council of Ministers (RCM) N. 55/2018 (DR 2018) approved the National Strategy for Nature Conservation and Biodiversity 2030. This policy recognizes that forest fires endanger biodiversity, and states that Portugal should be in the vanguard of economically valuing ecosystem services. In the following year, RCM N. 121/2019 (DR 2019b) launched the first Ecosystem Services Payment Program in Rural Spaces in the country. This program seeks to recognize the many significant contributions of forests that are not valued by common markets, such as erosion control, carbon sequestration, regulation of the hydrological cycle, biodiversity conservation, reducing susceptibility to fire, and improving landscape quality. Moreover, since 2014, Portugal has implemented a specific tax on fossil fuels. Law N. 82-D/2014 (DR 2014) changed the environmental fiscal norms and created the Addition Tax on Carbon Emissions that is applied over specific energy sources. The revenue collected through this taxation is directed to the Portuguese Environmental Fund, created by Decree-Law N. 42-A/2016 (DR 2016). This Decree-Law unified other environmentally focused funds, namely the Portuguese Carbon Fund, the Environmental Intervention Fund, the Water Resources Protection Fund, and the Fund for the Conservation of Nature and Biodiversity, incorporating their objectives and designated responsibilities (Environmental Fund 2021). Table 1 summarizes the scope of topics of projects that the Environmental Fund supports.

Scope of projects funded by the Portuguese Environmental Fund
Climate change mitigation
Adaptation to climate change
Cooperation in the area of climate change
Carbon sequestration
Use of the carbon market to meet international targets
Encouraging the participation of entities in the carbon market
Efficient use of water and protection of water resources
Sustainability of water services
Prevention and repair of environmental damage
Fulfillment of national and community goals and targets for urban waste management
Transition to a circular economy
Protection and conservation of nature and biodiversity
Training and awareness in environmental matters
Research and development in environmental matters

Table 1: Objectives of the initiatives sponsored by the Portuguese Environmental Fund. Source: Environmental Fund (2021)

In the context of this work, it is relevant to highlight that this Fund can sponsor measures related to carbon sequestration, prevention and repair of environmental damage, and protection and conservation of nature and biodiversity. Considering this background, the objective of this study is to estimate the monetary carbon savings of avoiding wildfires in five Mediterranean countries, namely France, Greece, Italy, Portugal, and Spain, as these countries historically have a high incidence of wildfires (Narayan et al. 2007; Vilén and Fernandes 2011;

San-Miguel-Ayanz et al. 2021). This part of the study is done using historical wildfire emissions data and the auction prices in the EU Emissions Trading Scheme (EU ETS). Portugal is further studied since the country has a new ecosystem services payment policy, a carbon taxation over energy sources, and an Environmental Fund, designed to support, among other initiatives, carbon sequestration, and biodiversity conservation measures.

2. Materials and Methods

2.1. Approach

This study is conducted in two parts, as illustrated in Figure 1. The first part of the analysis focuses on Mediterranean countries using data from the European Carbon Market and previously published emissions data (Vilén and Fernandes 2011). For the second part, which analyzes Portugal, the Addition Tax on Carbon Emissions values replace the data from the EU Carbon Market.

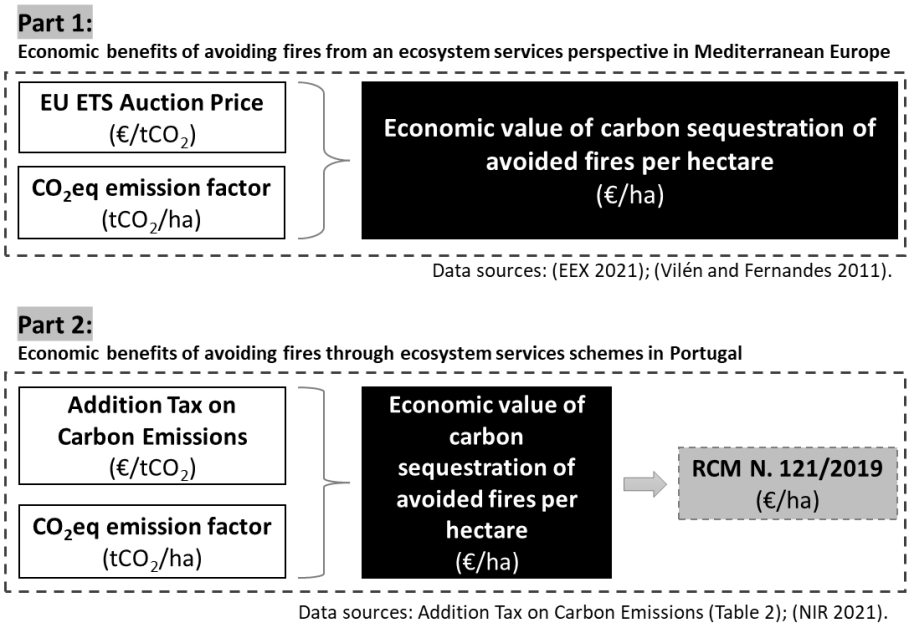

Figure 1: Framework employed. White boxes represent data input, black boxes the results of the calculations, and grey box the legislation used to compare and discuss the results

The analyses are further described in the following subsections.

2.2. Carbon values

2.2.1.Mediterranean countries

The auction prices in the EU ETS in 2020 are used as the reference to convert and estimate the monetary benefits of avoiding CO_2 emissions. The EU ETS is the oldest major carbon market in the world, and it is still the largest one. It is a central component of the European efforts to combat climate change and it is considered a key tool for decreasing greenhouse gas emissions cost-effectively (European Commission 2020b). Figure 2 shows the variation of the auction prices in 2020.

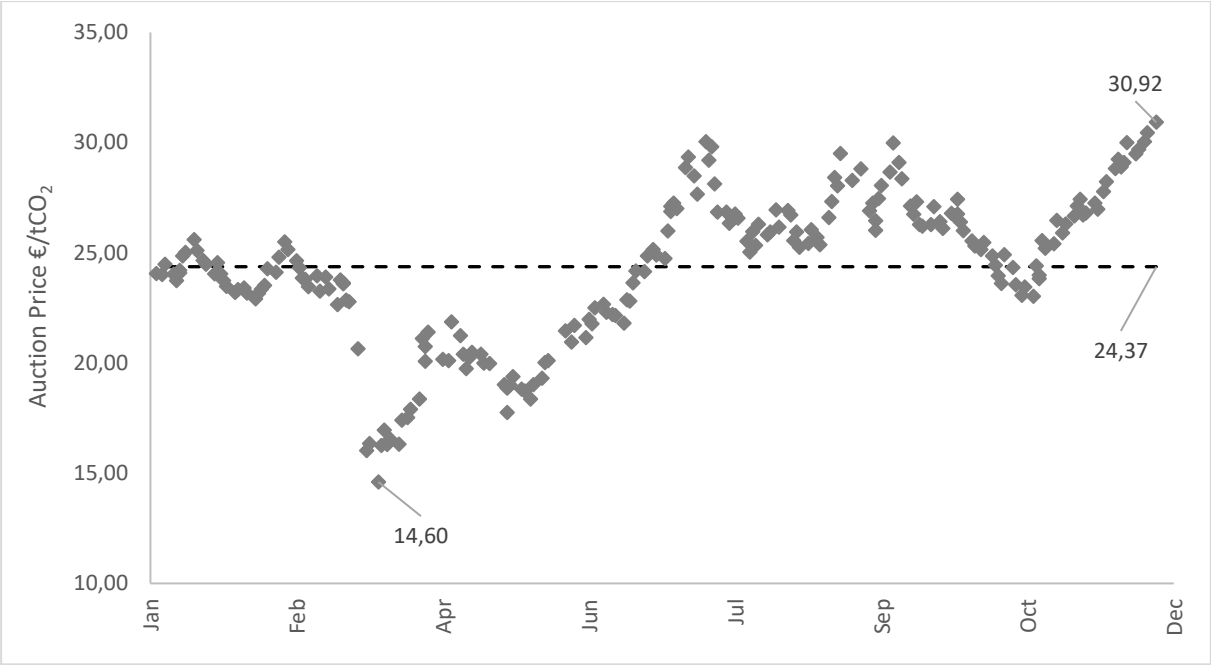

Figure 2: Variation of the auction price in the European Union Emissions Trading Scheme in 2020. The dashed black line shows the auction price mean value for that year. Data source: EEX (2021)

Carbon markets are a popular instrument to mitigate CO_2 emissions and are considered to be cost-effective (Fan et al. 2017). As shown in Figure 2, the auction prices in 2020 stretched from 14.60 €/tCO_2 up to 30.92 €/tCO_2. The mean value of 24.37 €/tCO_2, along with the minimum and maximum auction values are used in the subsequent calculations, connected to the Mediterranean countries.

2.2.2. Portugal

In the case of Portugal, an additional calculation is made using the Addition Tax on Carbon Emissions as the reference. The Addition Tax on Carbon Emissions was created by Law N. 82-D/2014 (DR 2014). Table 2 shows the values this tax has had from 2016, the year it started, until 2021.

Year	Addition Tax (€/tCO2)	Source
2016	6.670	Ordinance N. 420-B/2015 (DR 2015)
2017	6.850	Ordinance N. 10/2017 (DR 2017a)
2018	6.850	Ordinance N. 384/2017 (DR 2017b)
2019	12.740	Ordinance N. 6-A/2019 (DR 2019a)
2020	23.619	Ordinance N. 42/2020 (DR 2020b)
2021	23.921	Ordinance N. 277/2020 (DR 2020a)

Table 2: Progression of the Addition Tax on Carbon Emissions through the years

The value of the Tax for each year (n) is calculated in the previous year (n-1) as the arithmetic mean of the price resulting from auctions of greenhouse gas emission allowances, conducted within the European Union Emissions Trading System, between July 1st of year n-2 and June 30th of year n-1. This Tax is levied over petroleum and specific energy sources, and the revenue collected goes to the Portuguese Environmental Fund. The Addition Tax values have been increasing throughout the years, following the overall increasing trend observed in the auction prices within the EU ETS.

2.3. Carbon savings by Avoiding Fires

The approach employed in this study is similar to the work of Matzek, Puleston, and Gunn (2015), which used the auction prices in the Californian Carbon market to estimate the value of carbon stored in riparian vegetation.

2.3.1. Mediterranean Countries

Data on wildfire emissions and burned areas for the Mediterranean countries were obtained from the work of Vilén and Fernandes (2011). The authors estimated the annual average fire emissions and average burned area for France, Greece, Italy, Portugal, and Spain, as is shown in Table 3.

Country	Annual average fire emissions (tCO2)	Average burned area (ha)
France	1,340,682	28,460
Greece	358,509	49,044
Italy	5,816,367	118,022
Portugal	4,408,808	109,327
Spain	1,719,108	179,043

Table 3: Average emissions and burned area from 1980–2008.
Adapted from: Vilén and Fernandes (2011)

To calculate the average emission factor (in tCO_2/burned ha) for every country, Equation (1) was used:

$$Average\ emission\ factor\ (tCO_2/ha) = \frac{Annual\ average\ fire\ emissions\ (tCO_2)}{Average\ burned\ area\ (ha)} \quad (1)$$

These results are shown in Table 4. To estimate the monetary value of the carbon savings of avoided fires, the average emission factors for every country were multiplied by the average auction price of 2020, along with the year's highest and lowest values. Equation (2) shows this calculation:

$$Carbon\ savings\ \left(\frac{€}{ha}\right) = Average\ emission\ factor\ \left(\frac{tCO_2}{ha}\right) \times Auction\ price\ \left(\frac{€}{tCO_2}\right) \quad (2)$$

These results are shown in Figure 3.

2.3.2. Portugal

For Portugal, the average emission factor was determined using data from Table 4(V) of the Common Reporting Format from the Portuguese National Inventory Report on Greenhouse Gases, 1990-2019 (Portuguese Environmental Agency 2021). This was done by adding the implied emission factor of every reported gas (in tCO_2/ha) times their global warming potential (100-year time horizon, as is done in the report). This calculation was made for each of the 29 reported years, following Equation (3):

$$CAverage\ emission\ factor\ \left(\frac{tCO_2}{ha}\right) = CO_2\left(\frac{tCO_2}{ha}\right) \times 1 + CH_4\left(\frac{tCO_2}{ha}\right) \times 25 + N_2O\left(\frac{tCO_2}{ha}\right) \times 298 \quad (3)$$

The premise of this calculation is that if these wildfires had been avoided, the associated emissions would have been prevented, and this carbon mass would still be sequestered in the forest ecosystem. These results are shown in Figure 4.

Lastly, the estimation of the economic value of the carbon sequestration annually provided per hectare by avoiding fires was done by multiplying the highest (28 tCO_2/ha), the mean (20 tCO_2/ha), and the lowest (11 tCO_2/ha) average emission factors by the Addition Tax values. This was done to illustrate the full range of possible emission factors and it included all

Addition Tax figures to show the temporal trend of this service's value. Equation (4) shows the calculation.

$$Carbon\ savings\ (€/ha) = Average\ emission\ factor\ (tCO_2/ha) \times Addition\ tax\ value\ (€/tCO_2) \quad \textbf{(4)}$$

These results are shown in Figure 5.

3. Discussion

3.1. Mediterranean countries

For the Mediterranean countries, the annual average emission factors, shown in Table 4, varied from 7 tCO_2/ha in Greece going up to 49 tCO_2/ha in Italy. This indicates that each country has a different level of economic benefit when it comes to avoiding wildfires. Greece benefits the least and Italy the most in what concerns the maintenance of carbon storage.

Country	Annual average emission factor (tCO2/ha)
France	47
Greece	7
Italy	49
Portugal	40
Spain	10

Table 4: Estimation of the annual average emission factor based on the work of Vilén and Fernandes (2011)

The differences in emission factors are mainly due to changes in fuel compartments (deadwood, litter, branches, and foliage) composition linked to the idiosyncrasies of the forest ecosystems of each studied country (Vilén and Fernandes 2011).

These variations in the carbon sequestration capacity of each forest ecosystem are reflected in the estimation of the monetary value of the carbon stored, as shown in Figure 3.

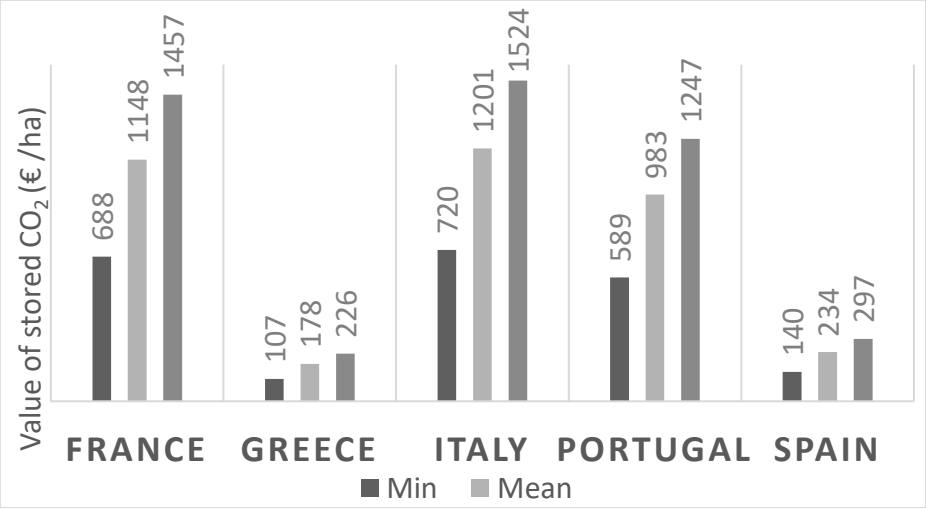

Figure 3: Estimation of the monetary savings associated with avoiding wildfires in the studied Mediterranean countries

In the least favorable scenario, considering the lowest auction price, the value of the carbon stored by avoiding fires varied from 107 €/ha in Greece up to 720 €/ha in Italy. In the most favorable scenario, the same countries would have economic benefits in the order of 226 €/ha reaching 1524 €/ha. This type of metric, as proposed in other studies (Matzek, Puleston, and Gunn 2015; Barbier et al. 2020), is important to help decision-makers in determining how much to invest in biodiversity conservation and wildfire prevention measures. If an

environmental policy requires an investment that is lower than the value of the ecosystem services provided by nature, it becomes, beyond an ethical choice, a sound economic investment. In this sense, Portugal is further analyzed, as the country already has a payment for ecosystem services policy in place (DR 2019b).

3.2. Portugal

For a deeper analysis of the Portuguese policy scenario, the National Inventory Report emissions data was employed, as they are the official governmental figures. Figure 4 shows the annual average emission factors for Portugal from 1990 until 2019.

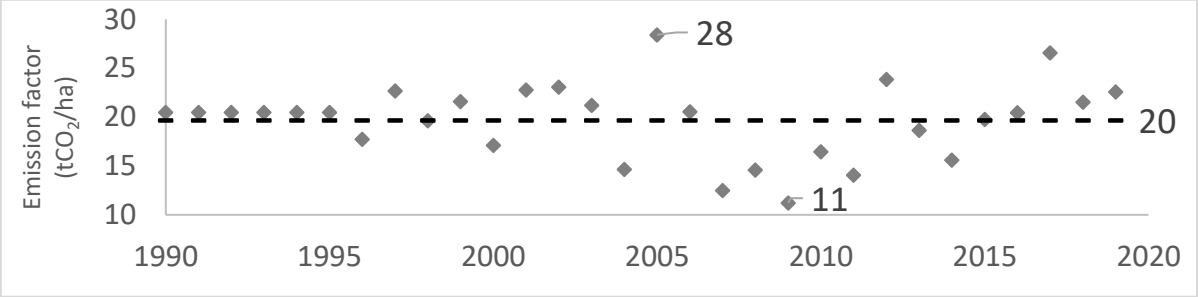

Figure 4: Annual average emission factors for Portugal from 1990 until 2019.
Data source: Portuguese Environmental Agency (2021)

The Emissions from Biomass Burning (Table4(V)), from the Common Reporting Format of the National Inventory Report) were first introduced in the Portuguese National Inventory Report of 2016. The values for the years before that were estimated retrospectively, which resulted in some of them being equal (1990-1995), due to data availability. The changes in the emission factor values through time are mostly caused by differences in each year's fuel and fire traits. This also explains the differences observed for Portugal between the references analyzed in the present study, as they refer to data gathered in distinct periods, 1980-2008 in the first part of the analysis (Vilén and Fernandes 2011), and 1990-2019 in the second (Portuguese Environmental Agency 2021). The variation of the carbon lost to wildfires is directly reflected in the monetary savings associated with avoiding fires in Portugal, as is shown in Figure 5.

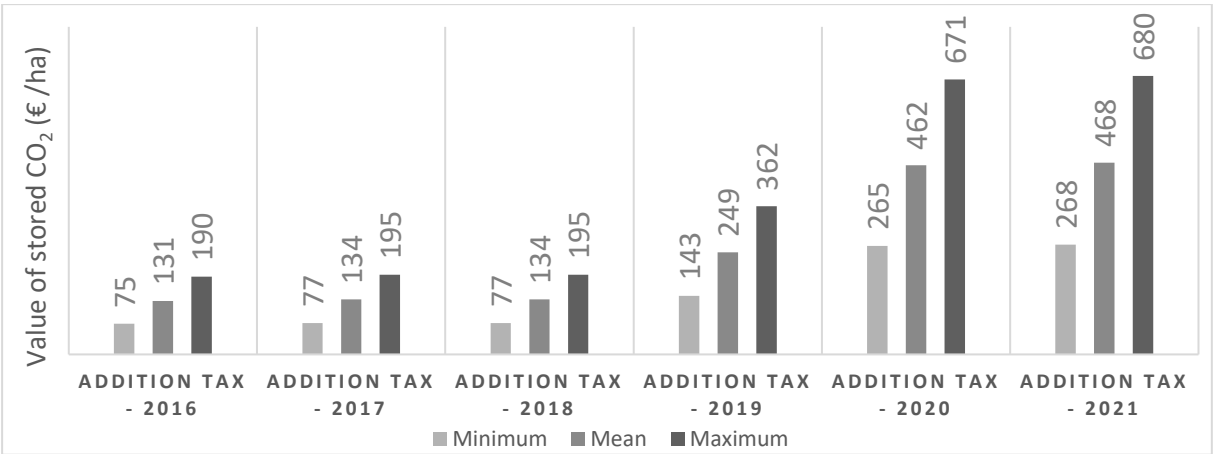

Figure 5: Estimation of the monetary savings linked with avoiding fires in Portugal

As shown in Table 2, the Addition Tax value has been increasing through the years, following the rise in the auction prices held within the EU ETS. This market behavior resulted in higher values for the carbon sequestered in the forest ecosystems through time. The monetary value of the carbon stored by avoiding fires varied from 75 €/ha in the least favorable scenario and goes up to 680 €/ha in the most favorable. This range of values provides an estimation of the

carbon sequestration service that the Portuguese forests provide when wildfires are avoided, which can serve as a reference for designing PES schemes.

Portugal currently has a PES initiative in place that was instituted by RCM N. 121/2019. Presently, there are two experimental projects being conducted in the country in Protected Landscape of Serra do Açor and Tejo Internacional Natural Park. In both cases, according to the characteristics of the land, the incentives paid annually for the ecosystem services provided by the forest vary between 5 and 20 €/ha. When comparing the range of the value of the incentives (5–20 €/ha) with the range of the values estimated for the carbon sequestration service (75–680 €/ha), it is possible to see that higher investments in the part of the country would still have a positive return, even if only considering the carbon stored by avoiding fires.

Indeed, the largest contributor to the Portuguese emissions is the energy sector, accounting for 70 % of total emissions in 2019 (Portuguese Environmental Agency 2021), and in comparison emissions from wildfires might seem neglectable, as they account for less than 1 % of the emissions of the same year. However, avoiding wildfire emissions is not the only relevant matter, as investing in forest conservation, especially through fire prevention, provides various other ecosystem services. The results of this work strongly suggest that, even if neglecting all the other economic benefits provided by the forest ecosystem services, just the carbon sequestration it offers is enough to economically justify investing in forest and fire management.

In this sense, the legislators acknowledge in RCM 121/2019 that there is a need to research more methodologies to estimate the incentives' value more accurately, better reflecting the value of the services provided by forests. Furthermore, ecosystem services-based solutions, such as PES initiatives, have been described as having the potential to offer co-benefits for implementing holistic policies such as the Sustainable Development Goals (Yang et al. 2020). From the State's perspective, there is strong evidence suggesting the benefits of investing in forest and fire management, but if it is not economically interesting for the landowners, it is unlikely that they will change from their known agricultural practices to focus on habitat restoration (Matzek, Puleston, and Gunn 2015; Evison 2017).

Additionally, carbon taxation is considered an interesting funding option for forest conservation actions (Barbier et al. 2020). In this context, the results of this study, which used carbon taxation as a monetary reference, indicate that it economically makes sense to invest more in protecting Portuguese forests against fires, and higher investments to protect the forests will likely lead to even superior economic benefits. As mediterranean-type ecosystems have for long provided classic cases for comparative ecological function studies (Rundel, Montenegro, and Jaksic 1998), it is likely that these results also apply to other countries in these regions.

4. Conclusions

Forests are efficient carbon sequestration systems (Liu and Wu 2017), and the many ecosystem services they provide contribute greatly to reducing CO_2 in the atmosphere. This is also true for the Mediterranean forests, as this study demonstrated. Furthermore, by investing in avoiding wildfires, a considerable amount of carbon emissions would be avoided, and the economic value of the forest and its ecosystem services would remain higher. The data set used in this study, despite accounting for 30 years of fire occurrences, is not the most recent. In this sense, future work might expand the analyses using more current data. As fire

intensity is expected to increase with climate change (Ruffault et al. 2020), investing in forest conservation might prove to be even more economically attractive.

The benefits of mutually addressing climate change and biodiversity loss are notorious (Barbier et al. 2020). However, it is also known that carbon sequestration payments alone are not likely to lead private landowners to shift from agricultural activities to habitat restoration (Matzek, Puleston, and Gunn 2015; Evison 2017).

Despite the intrinsic uncertainties in estimating wildfire emissions, mainly linked to a lack of data regarding fuel composition and fire characteristics, it was possible to provide initial economic estimates for Portugal that strongly suggest that investing in wildfire prevention, through conservation measures, is cost-effective. In this regard, the results for Portugal indicate that the value of the carbon sequestration service provided per hectare by avoiding forest fires likely surpasses the value of the incentive awarded by the Ecosystem Services Payment Program in Rural Spaces (DR 2019b). In this sense, it is economically and environmentally reasonable to revisit and reassess the values of this incentive. Further attractiveness to landowners, could perhaps strongly help in promoting the restoration of ecosystems, building fire resilience, and developing more sustainable agricultural practices.

Finally, the results obtained for Portugal are likely relevant for other Mediterranean countries, especially the ones which tend to exhibit higher wildfire emissions, such as France and Italy. The analysis framework developed for this study could be employed in these nations to more accurately assess their benefits in investing in forest conservation and fire prevention.

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