

Article

Study of Forest Productivity in the Occurrence of Forest Fires in Galicia (Spain)

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Abstract: The occurrence and intensity of forest fires is a phenomenon in which factors of various kinds converge, including climatic, physiographic, socioeconomic and territorial, among others. While the scientific literature has been stating that the causes of fires are related social conflict, other factors must also be considered for a more thorough analysis. In Galicia (northwest Spain), human-caused fires account for up to 95% of the total annual fires, highlighting the importance of examining in detail social and/or economic factors that may influence the occurrence or absence of this type of phenomenon. This paper discusses the influence and weight of forest productivity and the potential economic value of wooded areas on the incidence of forest fires in private mountains of collective ownership (*montes vecinales en mano común*). Our results indicate that the presence of productive wooded areas of the region determines a lower incidence, both in terms of the number of forest fires and the area affected. It was found that in areas where there was a loss in productivity, the fire rate increased by almost 36%. It is also observed that in MVMCs with productivity gain, the incidence of fires in shrubland areas was 46.26% higher than in wooded areas, while in MVMCs with productivity loss, the occurrence of fires in shrubland areas was 18.95% higher than that observed in wooded areas.

Keywords: forest fires; productivity; collective private property



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1. Introduction

Fire is one of the greatest environmental risks for people and their goods [1–5], a risk that, in recent decades, has been growing in size, severity and frequency [6,7]. Nearly two million fires [8] are recorded worldwide annually, causing significant environmental, economic and social damage [9–12]. In particular, some 45,000 forest fires occur in Mediterranean Europe each year, affecting an annual average of 0.5 million hectares [13–15]. Moreover, a fraction of forest fires become “extreme forest fires” or “large forest fires”, either because of the considerable physical, ecological and social dimensions generated, or by exceeding the ability to control the means of extinction [8].

The socio-economic and environmental gravity of forest fires is related to certain activities with a risk of starting fires in many regions [15–18]. Thus, in addition to those aspects that refer to the flammability of forest fuel, such as foliar size and density, content in volatile oils and resins [19,20], plant physiology and ecology [21,22] and the presence of remains of plant material [23,24], the scientific literature shows that there is a certain relationship between forest fires and social conflicts or human pressures [25–28]. It is therefore important to analyse socioeconomic factors in the study and evaluation of forest fires, whose role is currently more diffuse or unknown [29–32].

Several studies on the topic indicate that the unemployment rate, the realization of certain livestock or forestry practices, the degree of agricultural parcelling, the undervaluation of agricultural land, the abandonment of agricultural activity and the increase in forest area, population decline or changes in rural population density are some of the socio-economic

variables of relevance in the occurrence of fires worldwide [29,33–37]. Depopulation in areas of urban–forestry interface would be statistically related to an increase in the number of fires in these areas [38–41]. The degree of poverty of a region [12,42,43] or the existence of “ineffective” forest policies are other socio-economic factors studied that would promote the abandonment of agricultural land. This would lead to the abandonment of agroforestry management practices and increased fire risk [44,45]. What has not been sufficiently studied is the role of forest productivity or land value in the occurrence of forest fires, yet we understand that this is a key factor in regions with high fire intentionality. In areas such as Galicia (Spain), for example, where we will focus our study, highly productive *Eucalyptus globulus* plantations are barely affected by forest fires. In fact, during the period 2000 to 2013, the average incidence of forest fires on *Eucalyptus globulus* was 7.8%, with an occupancy rate of 20% [46]. This may lead us to conclude, at first, that there is an inverse relationship between forest productivity and fire occurrence—because why is it that some of the most flammable species are not attacked by forest fires, while less productive or less valuable species are? However, this relationship needs to be analysed further, as productivity is, after all, only one of many factors that can influence the occurrence of forest fires. This concurrence of multiple factors makes it very difficult to establish a technical-scientific “cause–effect” relationship between forest fires and forest productivity.

Focusing on the value of land and its current and potential productivity, this socio-economic factor is key to the use and management of a territory, especially when forest productivity, both globally and in Europe, has been progressively increasing in the 20th and 21st centuries [47,48]. Thus, FAO notes in its Global Forest Resources Assessment [49] that forest stocks have increased per area unit globally and in all regions, from 132 m³/ha in 1990 to 137 m³/ha by 2020. However, the occurrence and magnitude of forest fires have increased over the past decade, and the impact of forest fires is expected to increase in the future. Despite the great economic efforts made in the fight against fires [43,50–52], the years 2017 and 2018 were two of the worst years in the Mediterranean region in terms of the number of forest fires that occurred, burning more than 800 thousand hectares in Spain, Portugal and Italy alone [53]. In Galicia, more specifically, 2017 was the worst year in terms of burnt area during the same period [54].

Notwithstanding the above, the occurrence of fires does not affect all forest lands equally. Usually, younger, higher-density forest lands and more productive lands show greater susceptibility to forest fires [21,47,55,56]. However, arson fires occur more frequently in less productive forest areas. The aim of this paper is to analyse the possible statistical relationship between forest productivity and the occurrence of forest fires. In other words, we aim to answer the following questions: are there fewer fires in forests with higher productivity? Does an increase in the value of land and trees lead to a decrease in the number of fires?

2. Materials and Methods

The Autonomous Community of Galicia, a region located in the northwest of Spain (Figure 1), is organized administratively in four provinces with a total of 313 municipalities and 3793 parishes, with an average population density of 91.35 hab/km² spread over more than 30,000 population centres, although most of its population is concentrated in the coastal strip. The study area is a region of extensive agroforestry tradition and high potential productivity [57], being approximately 61% (1.8 million ha) of its forest area territory [58]. With more than 1.4 million wooded hectares, and an average growth of 12.3 million m³ per year of wood, Galicia contributed just over 9.7 million m³ in wood shorts in 2019 (almost half of the annual timber cuts in Spain), an annual rate of use clearly increasable, under sustainability criteria, according to official statistics [58]. The most relevant species in the region include *Pinus pinaster* Ait., *Quercus robur* L. and *Eucalyptus globulus* Labill [59]. Climatologically, Galicia has large differences between its coastal and inland areas. Average annual rainfall varies between 800 and 1000 mm in inland areas, and 1600 and 1900 in coastal areas. The average annual temperature is 13 °C, with

maximum temperatures exceeding 30 °C in the SE of the region, and winters with average minimum temperatures of 5 °C in the interior [60].

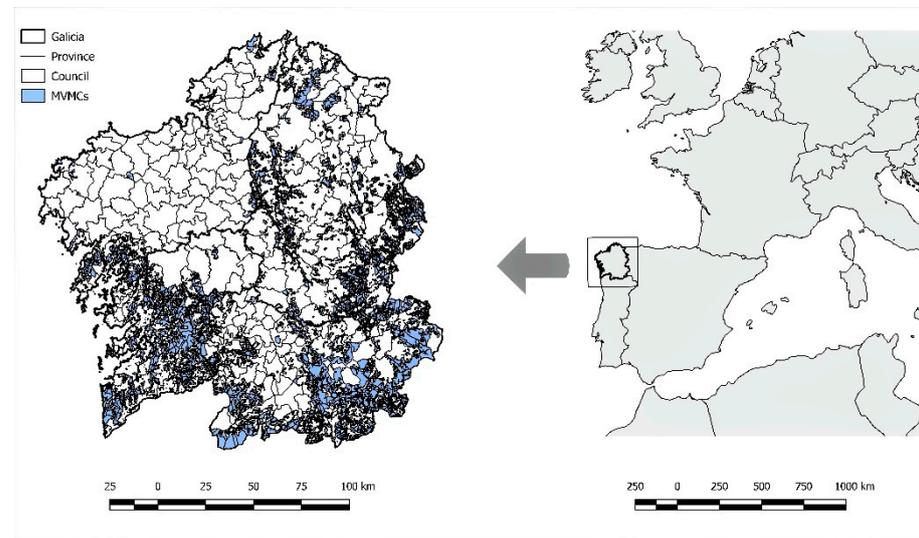


Figure 1. Galicia is a region located in the northwest of Spain.

Despite having bioclimatic conditions conducive to forest growth and production, Galicia has been the site of almost 45% (44.82%) of forest fires in Spain and 22.72% of the forest area burned at the state level between 1989 and 2014 [61]. Based on official statistics on forest fires, this region has seen more than 200,000 wildfires over the past 25 years, with an average of nearly 8000 fires per year and more than 26,500 ha of forest area burnt annually. More than 90% of the forest fires that occurred in Galicia were caused by human activity [28].

Regarding the structure of forest use property, approximately 99.5% of the Galician land is privately owned, and of this, almost 38% is collective private property (*Monte Vecinal en Mano Común* (MVMC) [59]. MVMC is of a Germanic character where the ownership of the mountain is attached to a group of neighbours (common) as a rural society and not as an administrative entity [62]. The common neighbours are simultaneously owners and managers of economic-productive territorial units [63].

In Galicia, there are 3326 MVMCs representing a total area of 663,488.96 ha and an average area of 219.48 ha per MVMC [58]. This type of collective property is distributed throughout almost the entire Galician region, although the inland provinces (Lugo and Ourense) cover the largest area of MVMC (just over 72% of the MVMCs in Galicia), as well as the territorial units of greater surface extension. The legal regime of the MVMC (democratic-assembly process) does not establish differentiated quotas of use and management between co-owners (commoners)—the neighbourhoods determine access to the land, equal and free for neighbours. The inheritance or sale of the rights of use is not possible [64]. Each inhabited house has a commoner right in the MVMC assembly. In 2019, there were 118,564 commoners in Galicia [58].

The special relevance of the MVMCs in the Galician forestry sector determines that this study on the problem of forest fires focuses on these areas. In fact, given that they have a larger surface area than other forest areas, they are key to rural management and forest planning in many rural areas of Galicia [63].

The main source of data was the MVMC Geographic Information System of Galicia, at the municipality and parish level, facilitated by the Galician public administration with competences in forestry (Consellería do Medio Rural, Xunta de Galicia) [65]. The resulting graphical and alphanumeric database was finally composed of a total of 3034 records and 19 fields, including the name of the MVMC, location, geographic coordinates, surface and classification date, among others.

The source of information of forest fires were the official databases of forest fires, which the state's public administration of forestry competences (Ministry of Agriculture, Fisheries and Food, Government of Spain) collected from 1968 to 2015 [66]. In our case, the period used was between 2009 and 2014, because it coincided with the date for which the results of the fourth Forest Map of Spain are cited and the year 2014 will be the last exercise available for public use. The data collected in this database were subsequently homogenized and optimized for storage in a Geographic Information System at the municipality and parish level of Galicia, generating a database of 2986 records and 31 fields.

Finally, the analysis of the forest productivity of Galicia to obtain an assessment of the forest mass present in each MVMC, started from the different work carried out by the research group PROePLA, of the University of Santiago de Compostela, for the years 1999 and 2009. These technical works are based on the comparison of the third and fourth Forestry Map of Spain (MFE3 1999 and MF4 2009), official mapping of the situation of forest masses at the state level, with a database composed of fields descriptors of the ecology and structure of the masses [67,68]. For the realization of this productivity analysis, each MFE was superseded with a spatial resolution grid 1 km² so that each of the existing forest formations could be assigned a "value" between 0 and 5, depending on the predominant forest species, the covered room fraction and the state of the forest mass.

The combination of these factors made it possible to obtain the defining value of each tesserae, or forest formation, so that the final value of the forest productivity of each grid, in productivity units, is the result of weighting the defining value of each of these formations with the area it occupies within the grid. That is, if a given tesserae occupies half of the grid, its value will represent 50% of the final value of the grid. In the same way, the global productivity of each MVMC was obtained by adding the value of each of the grids that coincide with the surface of the MVMC, so that each grid contributes to the final productivity of the MVMC a percentage that corresponds to its partial weight within the MVMC. With this procedure, the end result consisted of a grid of 30,606 cell with their respective productivity for the years 1999 and 2009. At the same time, the productivities corresponding to MFE3 and MFE4 were obtained for each of the MVMCs. The difference between these two MFEs makes it possible to find out which MVMCs gained or lost productivity during the 1999/2009 period, as well as to determine the land uses (or structural types) present in each class of MVMC (Figure 2).

GIS forest productivity raster and the GIS vector of forest fires were subsequently superimposed on the vector GIS layer of Galicia's MVMCs, which led to two new GIS layers reflecting the human-caused fires that occurred between 2009 and 2014, both in MVMCs where productivity gains had been achieved for 1999–2009, and where productivity had been lost in that period (Figure 3).

These two databases, which relate space–time distribution of fires to the forest productivity of MVMCs in the study region, consisted of 1707 records of mountains with productivity gain and 1327 mountain records with productivity loss. In order to technically deepen the subject matter of this study, a more detailed analysis of the managed databases was carried out, consisting of statistically observing what was happening in those 100 Galician MVMCs with the highest occurrence of fires for the period 2009–2014, as well as in those other 100 MVMCs in the region with a lower number of fires for that time interval. This procedure allowed for a more detailed comparison between wooded, disbursed, growing and artificial areas against forests (Figure 4).

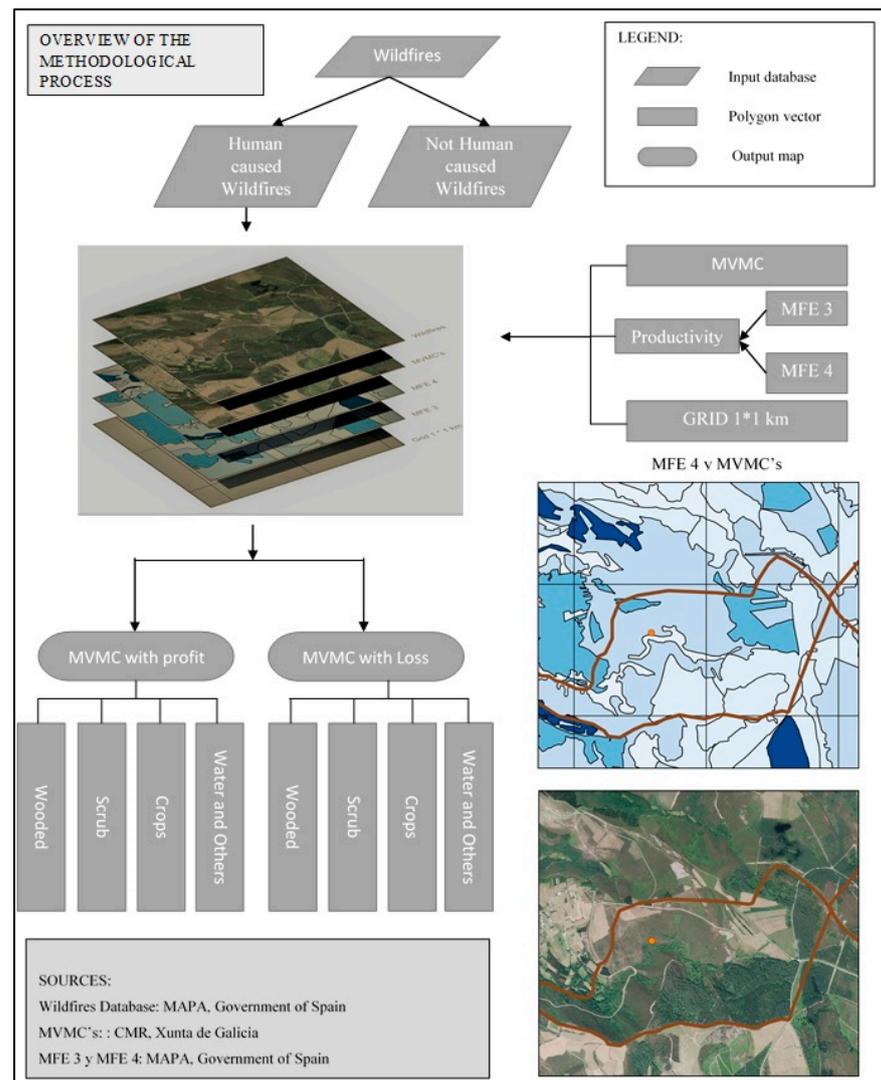


Figure 2. Overview of the methodological process. The superposition of various information layers (Forest Fires, MFE 3, MFE 4, MVMC) allows us to determine if after 2009, when MFE 4 was realised, the MVMCs that gained productivity during the period 1999/2009 suffer fewer forest fires.

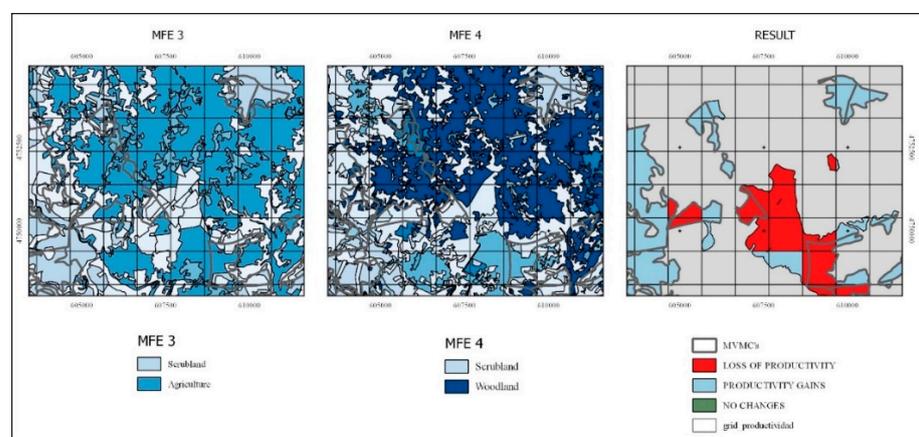


Figure 3. The productivity of each cell is the difference between the productivity of MFE 4 and MFE 3. The result is expressed as productivity gain, productivity loss or no change in productivity. The overall productivity of each cell is the sum of the productivity of each tesserae present in it.

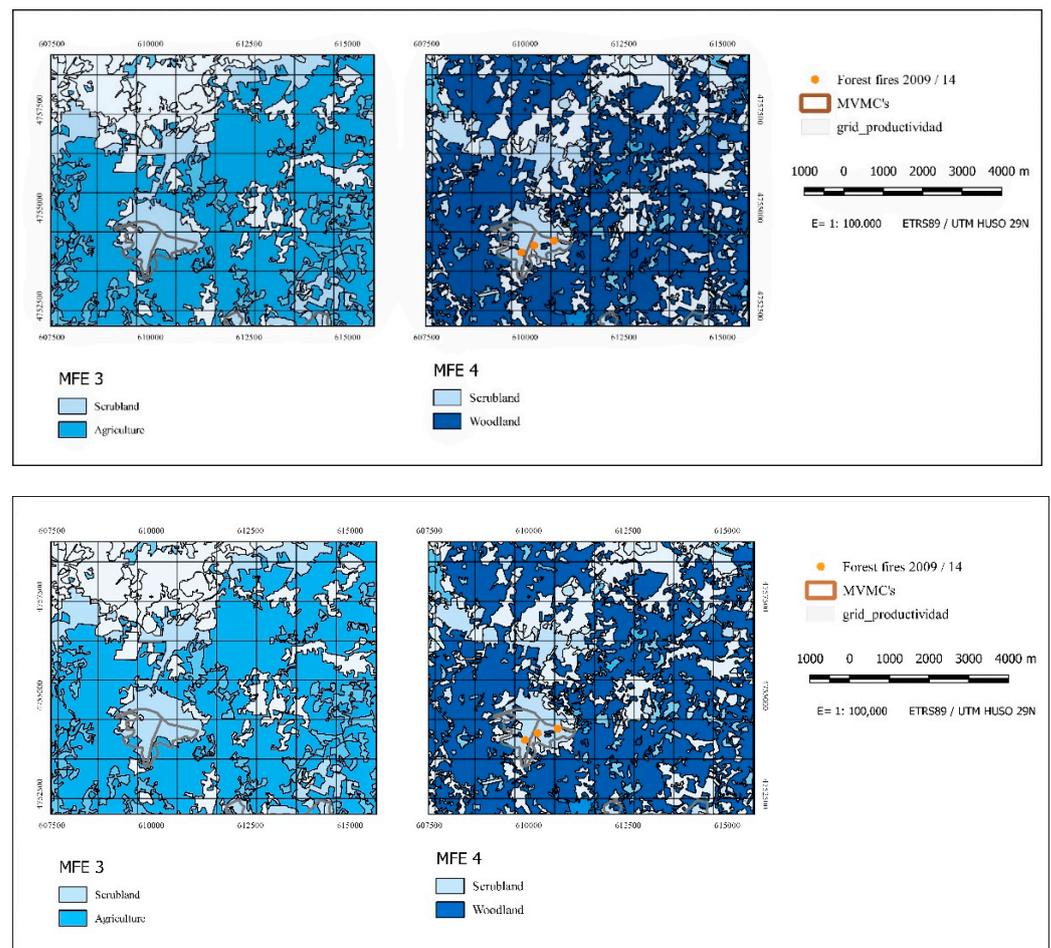


Figure 4. The figure shows the structural types (land use) collected from MFE 3 and MFE 4 and the forest fires that occurred from 2009 onwards, when MFE 4 was published. It can be seen that, in this case, the forest fires occurred in an area of scrubland.

3. Results

Forest productivity for the period 1999–2009 recorded an increase of 7.61%, regardless of the type of property. However, a widespread view of the forest area produces serious distortions, as the result will depend to a large extent on the territorial units considered. Thus, considering MVMCs in the analysis, Table 1 shows that the productivity of the overall forest area is 6.16% higher than that obtained specifically for MVMCs (1,579,048.36 vs. 1,487,349.82). It was also appreciated that the productivity of MVMCs that did not suffer fires as of 2009 (1,787,209.50 ha) was much higher than in any other group. It is worth noting the large difference in value, in productivity units, between MVMCs considered in general and those others that from 2009 did not suffer fires. These data made it possible to become aware of the loss in value that wildfires inflicted on the value of forest areas in the study region.

After analysing the productivity obtained, it was found that in a total of 1706 MVMCs (56.23% of the total), there was a productivity gain between 1999 and 2009 (Table 2), while in 1327 Galician MVMCs, productivity declined. These gains or decreases in productivity would be associated with changes in use during the decade of study, mainly linked to the loss in wooded surface area and increased scrubland surface area. In both cases, loss and gain, the percentage of MVMCs in which fires occurred was very similar, although slightly lower in the Galician MVMCs that gained productivity in 1999–2009 (31.71% versus 35.27%, respectively). In percentage terms, looking at the rate of fires per 100 ha of surface area in both groups, it was tested that the occurrence of fires during the period 2009–2014 was 35.99% higher in MVMCs that had lost productivity in the previous decade.

Table 1. Productivity differences (in units of productivity). The difference between the productivities obtained with the MFE3 and MFE4 makes it possible to check which MVMCs (or any other area) have gained or lost productivity.

GRID.	MFE 4 (09)	MFE 3 (99)	DIF	% Increase	% Gain	% Loss	% Changes
TOTAL FOREST SUP	1,579,048.36	1,467,439.35	111,609.01	7.61	58.86	38.05	3.08
MVMC	1,487,349.82	1,436,285.22	51,064.60	3.56	54.89	41.96	3.15
MVMC WITH FIRES 09/14	1,467,827.89	1,418,340.52	49,487.37	3.49	52.96	43.20	3.84
MVMC WITHOUT FIRES 09/14	1,787,209.50	1,772,454.91	14,754.59	0.83	57.00	40.89	2.11

Table 2. Differences between MVMCs with productivity gains and MVMCs with productivity losses.

	N°	Average Area	MVMC with Increase	N° of Fires	Fires/100 ha	Productivity
MVMC with GAIN PRODUCTION	1706	233.19	541	1559	0.39	1,696,860
MVMC with LOSS PRODUCTION	1327	201.78	468	1427	0.53	1,575,280

When considering separately the MVMCs in which there were fires between 2009 and 2014 (Figure 5), the occurrence of arson fires was also found to be slightly higher in areas that maintained or lost productivity between 1999 and 2009, compared to those where this parameter increased (50.05% compared to 49.95%), when the percentage of area represented by them is significantly lower (45.22% compared to 54.78%), as reflected in Table 3. These data would support the view that lower productivity would be associated with increased incendiary activity, as the number of fires is up 22.59% higher in those MVMCs that lost or retained productivity compared to those MVMCs with increased productivity during the study.

It is necessary to evaluate the land uses of each of the categories (productivity gain/loss) in the study MVMCs from the areas burned in these MVMCs, with bushes or trees, for the period 2009–2014 (Table 4). During this six-year period, the percentage of bush area affected by fires was much higher than that of the tree surface in both study categories (productivity gain/loss). Thus, even though the percentage of existing wooded area is significantly higher than the disbursed area in both MVMCs with productivity gain and productivity loss (53.04% and 55.95% wooded land versus 46.96% and 44.05% of bush land, respectively), the burnt-out area applied to the wood burned in MVMCs with gain (10.60% vs. 2.07%), reaching just over double the ratio for MVMCs with a loss in productivity (8.87% vs. 3.88%). These much-pronounced proportions would not seem to be explained solely by the higher rate of spread that fire has in bush areas, where fuel continuity is superior, but would indicate, rather, some relation to the forest productivity of that land.

Table 3. Changes in productivity and percentage of forest fires.

	Same Productivity		Increased Productivity		Loss in Productivity	
	% Grids	% Fires	% Grids	% Fires	% Grids	% Fires
Regular grid	3.08		58.86		38.05	
MVMC with fires	3.32	5.60	54.78	49.95	41.90	44.45
MVMC without fires	0.57		54.30		45.12	

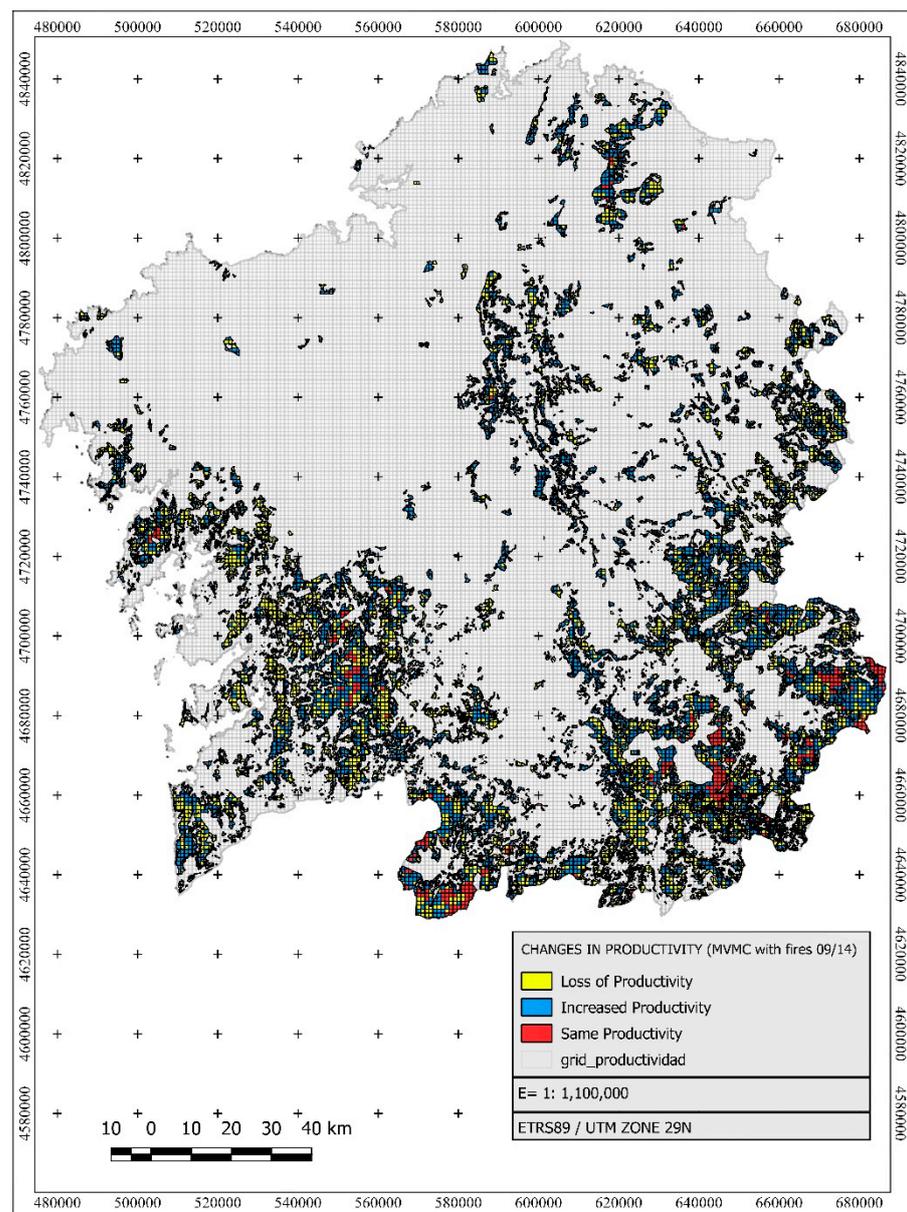


Figure 5. Productivity changes in MVMCs where wildfires occurred between 2009 and 2014. The difference between the values obtained from MFE 4 and MFE3 gives the cells in which productivity has been lost, gained or retained. By the weighted sum of these cells, the changes in productivity in each MVMC are obtained.

Table 4. Wooded and not wooded surfaces burned at MVMCs between 2009 and 2014.

Year	Burned Area per Year in Hectares and Percentage of Burned Area over Total Area							
	MVMC with Profit				MVMC with Loss			
	Not Wooded	%	Wooded	%	Not Wooded	%	Wooded	%
2009	2433.01	1.44	666.29	0.35	1224.33	1.19	281.71	0.21
2010	4256.66	2.52	422.92	0.22	1695.63	1.64	707.19	0.54
2011	7852.03	4.65	1473.58	0.77	3362.25	3.25	1772.27	1.35
2012	1640.01	0.97	551.35	0.29	1070.85	1.04	282.07	0.21
2013	1400.72	0.83	803.87	0.42	1680.2	1.63	1992.9	1.52
2014	324.38	0.19	35.99	0.02	133.34	0.13	62.69	0.05
Total	17,906.81	10.60	3954	2.07	9166.6	8.87	5098.83	3.88
		46.96		53.04		44.05	Arb:	55.95

Table 5 complements and confirms the above. As in Table 4, where we see that the wooded area in MVMCs with increased productivity is higher than that of shrublands (53.04% vs. 46.96%), Table 5 shows that this type of MVMC had a higher occurrence of fires in shrublands, not only in its cumulative value, but also, more consistently, in each annual observation. In percentage terms, the occurrence of fires in shrubland areas was 46.26% higher than in wooded areas. In MVMCs with a loss in productivity, while the ratio was not as pronounced, there was also a greater occurrence of fires in scrubland areas, an 18.95% occurrence.

Table 5. Fire occurrence (percentage) by structural types in MVMCs with profit and MVMCs with a loss in productivity.

Year	MVMC with Profit				MVMC with Loss			
	Wooded	Scrub	Crops	Water and Other	Wooded	Scrub	Crops	Water and Other
2009	35.98%	54.67%	5.95%	3.40%	41.85%	49.20%	7.35%	1.60%
2010	37.06%	55.59%	6.29%	1.05%	48.67%	46.46%	3.98%	0.88%
2011	38.85%	51.97%	7.87%	1.31%	45.91%	43.01%	8.97%	2.11%
2012	43.22%	50.00%	5.93%	0.85%	46.29%	45.85%	5.68%	2.18%
2013	49.46%	42.93%	5.43%	2.17%	51.32%	35.98%	10.05%	2.65%
2014	45.61%	52.63%	1.75%	0.00%	57.14%	32.47%	9.09%	1.30%
Total	40.08%	51.90%	6.28%	1.74%	46.85%	43.88%	7.43%	1.84%

Finally, the detailed examination of the structural types of the 100 MVMCs with the greatest occurrence of forest fires between 2009–2014, compared to the 100 MVMCs with the least occurrence of them, ratified what was previously observed. Thus, as we can see in Table 6, by intersecting the productivity value for 2009 with the sample of the 200 Galician MVMCs with the highest and lowest incidence of forest fires, large differences were verified between the two groups. Based on the resulting values, the percentage of wooded area in 2009 was much higher in those MVMCs with the lowest number of fires for subsequent years (2009 to 2014), compared to those other MVMCs with the highest occurrence of arson fires (65.60% vs. 35.98%). This trend was also appreciated for MVMC areas dedicated to agricultural/livestock cultivation (7.73% vs. 2.50%). By contrast, forest area percentages with lower value structural rates in 2009, such as scrubland, were visibly much higher in Galician MVMCs that suffered the most fires between 2009–2014 (58.51% vs. 25.15%).

Table 6. Percentage of structural types in the 100 MVMCs with the lowest occurrence of forest fires and the 100 MVMs with the highest occurrence of forest fires.

Type of Use	Lowest Occurrence	Highest Occurrence
Woodland	65.60	35.98
Scrub	25.15	58.51
Agriculture	7.73	2.50
Water and buildings	1.52	3.01

4. Discussion

The occurrence and magnitude of forest fires involves aspects of a very diverse nature [19], from those of a socio-economic, climatic or physiographic nature, to those concerning fuel or the availability and quantity of resources and means of extinction. Therefore, establishing a “cause-and-effect” technical-scientific relationship between forest fires and forest productivity often presents numerous difficulties. Moreover, this relationship between land value and forest fires has not been specifically and widely addressed by the scientific literature, so it is complex to contrast the results obtained in this article. However, Pausas and Bradstock, 2007 [69] or Van der Werf et al., 2008 [70] explained that fire activity can change along a productivity/aridity gradient. In wet and productive regions, where fuel is abundant, the determining factor for the fire regime would be climate, while in less productive ecosystems, the most decisive aspect would be fuel. In regions such as

Galicia, however, where the intentionality of forest fires is very high, the determining factor in the occurrence of forest fires, excluding causes such as conflicts, for example, of great importance would not be the climate or the flammability of the fuel, but the economic value of the existing forest mass.

Several authors have linked plantations of native species, which are usually highly productive, with increased fire occurrence. Among them we can cite Pausas and Ribeiro, 2013 [71] who analysed, on a global scale, the relationship between fires and productivity by studying the land ecoregions proposed by the World Wildlife Fund [72]. In their work, while citing the influence of the anthropogenic factor on the fire regime and the bias that this would introduce in the observations, the authors found a predictable pattern between fire and productivity, so that the latter would determine the occurrence of fires to a greater extent than the weather. In their study, Pausas and Ribeiro, 2013 [71] concluded the relevance of the risks associated with changes in land use and landscape management, as well as the introduction of non-native species, in the fire–forest productivity relationship, a fact that also been detected in our work. Similarly, in relation to the existence of allochthonous species and the vulnerability of a territory to forest fires, Gómez González et al., 2019 [18] concluded that the occurrence of forest fires in Chile has the greatest impact on exotic forest plantations; Reyer et al., 2017 [48] concluded that increased productivity, in the future characterized by increased disturbances, could trigger an increase in forest damage, especially if accompanied by a higher volume of standing; and Miranda et al., 2017 [73] emphasized the importance of land use changes and plant cover over biodiversity and forest fires, citing a greater number of fires after the substitution of native vegetation with allochthonous species. In this regard, McWethy et al., 2018 [74] found a strong selective “preference” for fires at exotic forest plantations, but also found that abundant fuels from highly productive areas rarely dried up enough to promote the spread of fire; thus, low net primary productivity would limit fuel availability despite seasonal drying.

Notwithstanding the above, the results of our study would show the opposite trend, since those MVMCs analysed with a lower incidence of fires always had a higher proportion of plantation forests (largely, plantations of allochthonous species). According to what we have observed, a higher productivity in the MVMCs of the study region seems to determine a lower occurrence of forest fires, while the loss in productivity led to an increase in the fire rate of up to almost 36%. This fact could be explained by the high degree of intentionality of fires in the study region, so that the likely most decisive aspect of the occurrence of forest fires in Galicia is the remuneration (or economic return) that the forest land represents for the owner. In other words, if the forest land represents an important source of income for its holder, the incidence of forest fires will be greatly reduced, as the same owner will ensure that it does; if, on the other hand, the land does not represent a source of income, the owner’s interest will be lower and, consequently, the forest fire will not be a problem for the owner. It is worth recalling the findings of Calvo de Anta et al., 2019 [46], when they state that the presence of eucalyptus cannot be associated with a higher incidence of fires, or the results obtained by Calviño Cancela et al., 2016 [75] for plantations of exotic species, such as *Eucalyptus globulus* Labill, masses that suffer little fire in Galicia, since such plantations usually have active management by their owners or managers, reducing the fuel load and, therefore, the risk of forest fire. These observations are ratified by Vega et al. 2021 [76], when they analyse the fires occurred in Galicia in October 2017, in which they observed a lower severity than expected due to the high average height of the canopy base of eucalyptus plantations, and with good management of surface biomass. As they state in their study, fuel management is more important than the species. However, this active management, which would reduce fuel and fire risk, would not be very common if the economic return value of that mass was not high.

Our results also contrast with those of Guo et al., 2014 [77], who, in a study on intentional fires in China, found no relationship between the type of forest and the occurrence of fires. In fact, regarding the possible relationship indicated above, our calculations show that the bush forest area that was burned between 2009 and 2014 was approximately three times

the forest area affected by fires in the MVMCs studied for that period (Tables 4 and 5), even representing in both strata very similar percentages. This could suppose that the possible dependence between productivity and occurrence of fires in MVMCs is not coincidental because, in the absence of such a relationship, the percentage of forest fires that would affect each type of coverage should be proportional to the occupied area. Taking into account the above the data obtained in this study—the occurrence of forest fires versus forest productivity in MVMCs—the existence of an inverse relationship between productivity and fire occurrence could be concluded, so it would be possible to say that those MVMCs in the region that have gained the highest productivity between 1999 and 2009, suffering fewer forest fires during the period 2009–2014 (Tables 1 and 2).

We also disagree to some extent with Gómez González et al., 2019 [18], who argue that agricultural activity is an important driver of fires, caused, above all, accidentally during agricultural work; and with Fusco et al., 2016 [78] and Balch et al., 2013 [79], who stated that the introduction of species such as *Bromus tectorum* would alter the fire regime by promoting fuel continuity and increasing the presence of fine fuel, increasing the number of fires. Our results show that MVMCs that initially had a higher percentage of area initially devoted to higher economic value use (for example agricultural crops-livestock) were also characterised by fewer wildfires. Although what these authors claim is true, because the introduction of these species facilitates the spread of fire, in areas such as Galicia, where there are mostly arson fires, the important thing would not be to evaluate the rate of propagation, but to find the cause that would lead to the appearance of the fire. The results obtained in this study show that MVMCs with fewer forest fires had a percentage of farmland that tripled that observed in MVMCs with the highest incidence of fires, something similar to planting forests or natural woodland; this suggests that the presence of high-value of the wood would act as a fire deterrent.

5. Conclusions

The methodology developed in this work, based on a systematic analysis of information relating to the type of property, land use and productivity of a territory, together with forest fires occurring over a given period of time, allows us to know to a greater extent the distribution and causality of fires in regions of high incendiary activity caused by man.

The results obtained show that MVMCs with a higher fraction of wooded forest area or higher economic value had a lower incidence of forest fires between 2009 and 2014, both in number of fires and in the affected area. Therefore, it is demonstrated that increasing the economic value of agricultural or forest land would reduce the occurrence of forest fires. What is worth money burns less, because there is no benefit in the occurrence.

The productivity increases detected correspond to areas where low productivity land uses have been replaced by more profitable ones. Improving or increasing the forest productivity of a territory, in this case, of an MVMC would therefore be associated with an improvement or increase in the use of these areas, either of the existing tree coverage, or capitalizing on the territory through its afforestation (if there was previously disbursed coverage). To this end, the valorisation or dynamization of agricultural land is decisive—first, through its correct planning and management, to subsequently implement and monitor a professional and active forest management based on the principles of sustainability (socioeconomic and environmental) inherent in forest systems and, taking into account current international demands in this field, also incorporating such silviculture, technical criteria of resilience and resistance of forest ecosystems. Therefore, in areas of high intentionality in the occurrence of forest fires, the prevention and fight against these claims should be based, instead of monitoring or equipment of prevention infrastructure and equipment, on the recovery of forest territory and its associated resources or values, especially on the improvement and/or sustainable increase in its productivity.

Of course, what has been observed does not imply that productivity is the only aspect to be taken into account in the occurrence of forest fires, as there are many other factors that affect it. Moreover, the scientific literature has not addressed this issue so far. However,

it seems to us that it is a very important factor in areas where most fires are caused by humans. New forest inventories or maps will allow us to confirm the findings of this analysis, and may even allow the study to be extended to other geographical areas.

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