VEGETATION FIRES IN ROMANIA: AN OVERVIEW

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ABSTRACT. – Vegetation fires in Romania: an overview. The main purpose of the present paper is to explore the current state of knowledge upon the occurrence and impacts of vegetation fires in Romania and to make a brief report on the sources of data concerning such events, in order to pave the road for further, more detailed studies upon the occurrence of vegetation fires in Romania. Using satellite images-based applications available at EFFIS we could observe that Romania is indeed impacted by many fire events every year. In addition, we worked with a large database provided by the General Inspectorate for Emergency Situations, that includes over 150,000 entries, regarding interventions of fire brigades on vegetation fires in Romania. Among other aspects, these data showed that the main regions for such interventions were the southern and western parts of the country and that the monthly occurrence of such events corresponds to timeframes typical for clearing agricultural lands.

Keywords: vegetation fire, land use, agriculture, impact, Romania.

1. INTRODUCTION

In the wide context of climate change, increased frequencies and intensities of weather-climatic hazards are observed (extreme temperatures, heat waves, droughts, thunderstorms, heavy rainfall over short periods of time etc.). Processes and phenomena associated to such hazards, like wildfires or floods are also more frequent. Less accelerated changes, resulted from the increase in the average temperatures and from the modification of the patterns of the climatic, hydrological and vegetation systems are also observed. Of course, all these phenomena have diverse manifestations around the world, with some regions being more impacted than others. In Europe, the most impacted are the Mediterranean area, the high mountains, and the Arctic area (IPCC, 2022). However, the effects of global warming can already be identified in the other regions as well, and their further expansion throughout the continent is expected in the future. In Romania, the areas most impacted by climate change are the extra-Carpathian regions (Bojariu et al., 2015) but in the long term, the effects of global warming will be increasingly felt in the other regions as well.

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The European Union has taken on the UN's Sustainable Development Goals, relevant "climate action" goals and measures being addressed in its European Green Deal. Through its policies, the EU aims for Europe to become the first climate-neutral continent by reducing anthropogenic greenhouse gas emissions to the level where the remaining emissions can be neutralized by natural/ anthropogenic processes of carbon sequestration.

However, the efforts of various states (and of the society in general) can lose their relevance and be offset by natural phenomena and anthropogenic accidents that release huge amounts of greenhouse gases into the atmosphere, some of which are accentuated, by positive feed-back loops, by global warming (e.g., the melting of permafrost and the acceleration of the decomposition of the organic matter stored in it, or wildfires). In some cases of large wildfires (e.g., the wildfires in Europe from the summer of 2022), greenhouse gas emissions can be so high as to offset months or years of efforts to reduce human-caused emissions.

2. GENERAL CONSIDERATIONS ON VEGETATION FIRES

Fire has always been a natural phenomenon in forests and grasslands, serving important functions in these ecosystems (McLauchlan et al., 2020). However, with the expansion of landscapes transformed by agricultural and forestry practices, wildfires began to be managed, primarily aiming to control their effects (e.g., suppressing forest fires to reduce damage). Thus, over time, the frequency of such fires decreased (Turco et al., 2016; Urbieta et al., 2019).

Recently, however, this trend seems to have reversed and important changes are being observed in the spatial distribution and frequency of wildfires in the world. At the European level, one can note an increase in the intensity and number of fires in the most common areas of such events (the Mediterranean area), as well as an increase in the affected surfaces in areas where forest fires were, until recently, episodic events (CMINE, 2020). The CMINE report names several factors that contribute to this evolution: *climate change* favoring the occurrence of fires through heat waves and longer droughts, *past occurrence of fires* in a specific area (which also indicates the population and public authorities' preparedness for such events), *rural and agricultural abandonment* (determining the expansion of unmanaged areas covered by forest or shrub vegetation) and *lacking forest management* that does not address fire risks (allowing the accumulation of biomass that can become fuel for fires, and the continuity of combustible elements over extended surfaces).

A vegetation fire is a complex process, in which several elements are simultaneously involved: a substantial amount of fuel (e.g., the accumulation of dry vegetation on meadows, pastures or other agricultural lands at the end of plants' life cycle or after harvesting; the accumulation of dead wood and other litter

elements in forests after tree falls or insect attacks; the accumulation of woody waste after logging), an ignition source (which is most often anthropogenic) and, of course, oxygen.

Weather can be a determining factor in the extent to which a fire self-limits or spreads rapidly over large areas, especially in homogeneous landscapes. The term "fire weather" is used in the specialized literature to describe a type of weather with certain features that can contribute to the occurrence of fires (low humidity, high wind speed, heatwaves, drought etc.). Current and projected climate change in Europe, marked by more frequent extreme positive temperatures, heatwaves, mild winters (including the reduction of the snow cover duration, leading to longer periods when the soil is dry and the vegetation more easily flammable) demonstrates the increased frequency and duration of periods with increased indices for this type of weather.

On the other hand, greenhouse gas emissions from large vegetation fires can be substantial, influencing, in turn, the climate. Studies have shown that this impact is multidimensional.

First, wildfires can transform forests from carbon deposits to greenhouse gas emitters, contributing to global warming. By substantially reducing the role of fire in the ecology of forests, modern silviculture has contributed to the emergence of the *fire paradox* - the more fire is suppressed, the more likely the occurrence of more intense fires through the accumulation of dry vegetation, dead wood, etc. That is why, in countries like the USA or Canada, there is the practice of prescribed burning, to create discontinuities in homogeneous forest landscapes and limit the spread of possible fires.

Second, ash and particles produced during combustion have significant effects when transported into the atmosphere and deposited on mountain glaciers or in the Arctic (by this, changing the albedo of the affected surfaces). But even smaller and less intense vegetation fires, such as those produced on agricultural land, can similarly affect the northern region of Europe; Warneke et al. (2010) showed that the burning of agricultural lands in southern Russia, a frequent practice during spring, contributes significantly to the increase in the amount of black carbon in the Arctic region.

Studies on the atmospheric impact of wildfires generally deal with air pollution and its effects on human health. Such studies have been carried out in Sweden (Tornevi et al., 2021) or Portugal (Tarin-Carrasco et al., 2021), to name just a few. Burning agricultural land can also consistently contribute to regional pollution (especially since it is a recurring practice, not just accidental episodes like most forest fires), and long-term exposure of people to smoke from these fires is not without consequences.

Except for the study by Stan et al. (2014), there is no research in Romania that analyzes the effect of wildfires on the environment and the health of the population. In the aforementioned study, the authors review the harmful effects of

burning agricultural land on soil fertility and draw attention to the effects of this practice on greenhouse gas emissions.

However, for an accurate view on the topic, an assessment of the scale of the phenomenon is necessary. Thus, the main objectives of the present paper are to explore the current state of knowledge upon the occurrence of vegetation fires in Romania, to verify the correspondence between the various data sources we have identified and to present a brief, preliminary report on the vegetation fires in Romania in terms of frequency and spatial distribution as it derives from the analyzed available data.

3. DATA AND METHODS

We have identified two main data sources that can be used for studying these aspects:

- Satellite databases. Vegetation fires are monitored at European level through the European Forest Fire Information System (EFFIS), a component of the Emergency Management Service (EMS) of the Copernicus program of the European Union. The applications available on the EFFIS website are integrated with GWIS (Global Wildfire Information System) and are based on the detection of thermal anomalies (equivalent to active fires) using MODIS (Moderate Resolution Imaging Spectroradiometer) and VIIRS (Visible Infrared Imaging Radiometer Suite) sensors on NASA satellites. National statistics available on the EFFIS website utilizing MODIS and VIIRS images include fires that affected land areas of at least 30 Ha. This database, although very informative on large fires, excludes many smaller wildfires that go undetected.

- Information from the fire intervention reports of the fire brigades. These reports are centralized by the General Inspectorate for Emergency Situations and include information such as: the date of the intervention, the duration of the intervention, the determining circumstance for the occurrence of the fire, the location of the fire (which is more or less precise - sometimes the data only being available at the county level) etc.

We were provided with such data from the General Inspectorate for Emergency Situations regarding the intervention of firefighters on vegetation fires, between 2000 and 2020. These data were processed by firstly eliminating any multiple entries (out of the 151,616 initial registered events, 682 were eliminated) and secondly, by locating the interventions at a county level. The defining categories for each intervention are: location (administrative unit), date of announcement, duration of the intervention, land use of impacted areas and the determining circumstance (probable causes).

We then uploaded the selected data in a GIS software and exported a synthetic map illustrating the main areas (on a county level) for the occurrence of

such fires in Romania. We further analyzed the data, in order to reach relevant conclusions upon the main types of fire events (considering the before mentioned categories), and to provide some statistical expressions of the analyzed phenomena.

4. DISCUSSION

Analyzing the components of the Fire Weather Index (FWI), the areas affected by fires in Europe and fire intensity, Carnicer et al. (2022) show that global warming causes a statistically observable change in the dynamics of wildfires by increasing their impact, increasing the fire-related risk for society and reducing the role of forests in carbon storage. Their observations were especially relevant in Southern Europe, including the southern part of Romania.

According to the statistics available on the EFFIS website, the Mediterranean countries were most impacted by fires (Portugal – 97,081.53 ha, Spain – 81,060.65 ha, Italy – 54,248.12 ha, Greece – 40,410.24 ha, Croatia – 14,242.82 ha, France – 12,998.71 ha). Compared to the frequent fires in the Mediterranean area, Romania does not seem to be a hot-spot for such phenomena. However, Romania and Bulgaria are also mentioned among the impacted states, with 22,514.88 ha, respectively 10,195.06 ha. Moreover, the online EFFIS database containing the number of active fires identified on satellite images between January 1, 2018 and December 31, 2021 shows a very large number of such events in Romania. The impacted areas are usually small, but their high frequency can be a risk factor for the environment and the population, and their cumulative greenhouse gas emissions can be significant.

By analyzing the areas affected by fires between 2002 and 2020 (using data available on the GWIS webpage), we have found that most fires occurred on agricultural land. Even though the percentage differs from year to year, the fires on cropland represent the widest category, followed (at a great distance) by the ones on other types of areas (including abandoned lands covered by vegetation), by grass and shrubland and finally by forests.

The situation is not necessarily specific to Romania, in many countries of the European Union the affected areas being mostly agricultural land. However, Romania is one of the most impacted by such phenomena. This finding suggests that here, vegetation fires are largely driven by agricultural practices. At a European level, a greater impact was found in Ukraine and in the European part of Russia (Hall et al., 2021). According to the GWIS database, the highest frequency of fires in Romania is found in the extra-Carpathian regions and, in particular, in the south of the country, but the other regions are not spared from such events either.

While analyzing the database deriving from data provided by the General Inspectorate for Emergency Situations, a database that includes 150,934 interventions by fire brigades at vegetation fires in Romania, we could note that the number of recorded interventions varies over the analyzed years (Fig. 1).

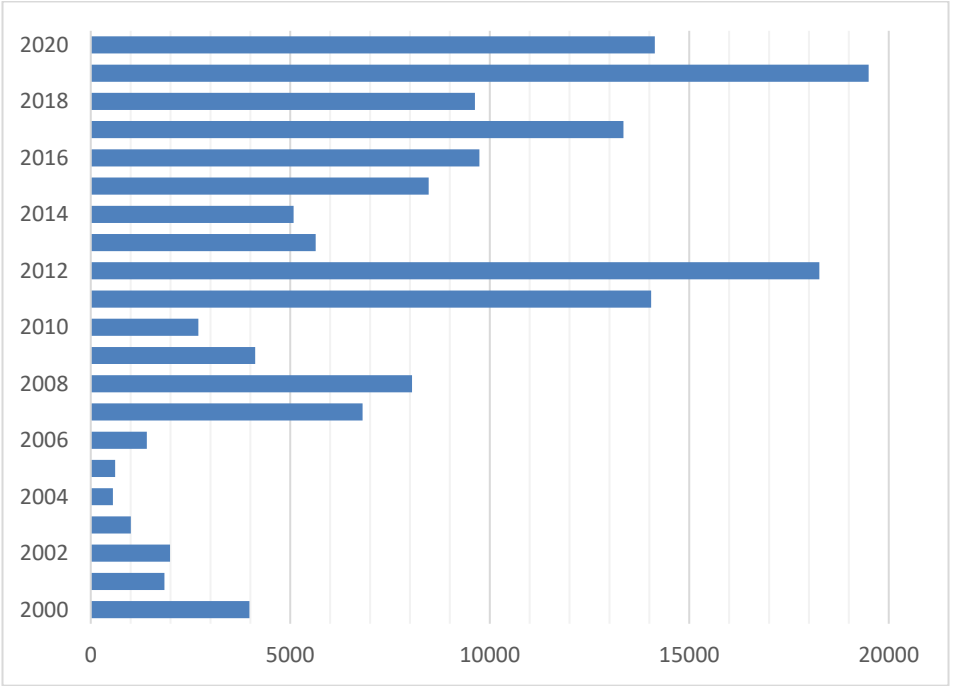

Fig. 1. The number of vegetation fires in Romania between 2000 and 2020 (Data source: General Inspectorate for Emergency Situations)

We can, on the one hand, observe some years marked by rather low numbers of vegetation fires, when under 1000 such events were registered. We are referring to 2004-2005, which was also a period of reorganization for the emergency intervention services in Romania. On the other hand, the highest numbers of interventions were registered in 2012 (18,262 interventions) and 2019 (19,495 interventions), and the general trend is upwards.

In the same database, in terms of the main types of land use of impacted surfaces, the registered vegetation fires occurred as follows: crop fields and stubble fields, forest, pastures and meadows, and other types of vegetation areas. Most interventions (76%) took place in the category of land described as *other vegetation* (e.g., dry vegetation on abandoned land).

When analyzing the number of interventions according to their duration, one can note that, for this type of vegetation, the interventions were generally shorter

than in the case of the other types of vegetation - in this case, half of them were under an hour (Fig. 2). Interventions lasting more than one hour accounted for 59% of the interventions for fires in stubble and crop fields, 75% of those on meadows and pastures, and 87% of those in forests. In total, 45.5% of performed interventions have lasted under one hour, and 54.5% over one hour. If we think of the duration of the intervention as a proxy for the scale of the incident, we can suppose that most fires were rather small events.

Regarding the yearly occurrence of such events, when analyzing the last 10 years of the series (that do amount to 78% of the total number of interventions in our database) we noted that, although there are variations from one year to another, in general, most interventions (34.5%) occur during spring. During autumn and summer, the registered events have rather similar percentages (29.3%, respectively 28.4%) while in winter there is the lowest occurrence, of only 7.8%. On a monthly basis, most interventions take place in March (22% of the total number of interventions), followed by August and September (16% each) and April, July and October (10% each). This distribution supports the hypothesis that most fires do have anthropogenic causes, since they tend to occur for sanitation of agricultural land before a new crop, to remove the dry vegetation from the previous year, or for clearing uncultivated land of unwanted vegetation.

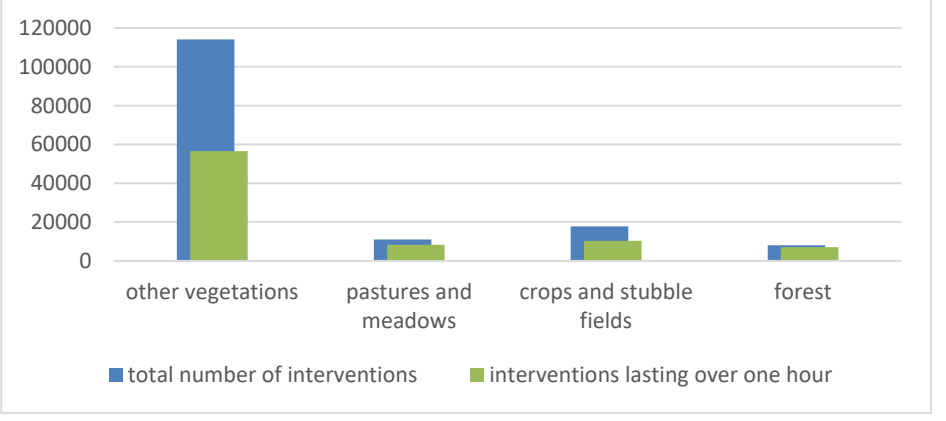

Fig. 2. The number of interventions by fire brigades on fires occurring on different types of vegetation, between 2000 and 2020 (Data source: General Inspectorate for Emergency Situations)

Analyzing the probable causes and circumstances of all analyzed vegetation fires, we noted that most fires (48%) were caused by open fires in open spaces (burning of dry vegetation, waste or stubble, starting a campfire, etc.). 16.2% of fires were caused by smoking in areas that are not/cannot be properly protected or even restricted places, 7.9% of fires were caused by arson, 2.1% by issues related

to the use of defective or improvised tools and equipment, or by sparks that might be emitted by agricultural machinery and 1% by children playing with fire sources. Only 0.3% of fires were caused by self-ignition, lightning and other natural phenomena. For 24.5% of the fires, there was no certain cause included in our database, and were classified as events triggered by "other circumstances".

There are some variations in percentages for the different types of vegetation categories, as observed in Figure 3. In all the analyzed types of vegetation, the majority of fires were caused by the open fires in open spaces, however, the percentages vary between 40% in the case of fires occurring on crops and stubble fields to 58% in the case of fires occurring on pastures and meadows, and 59% in the case of forests fires. Smoking was also a case more prevalent in the case of forests (19%) than for the other types of vegetations (16% for every other type of vegetation).

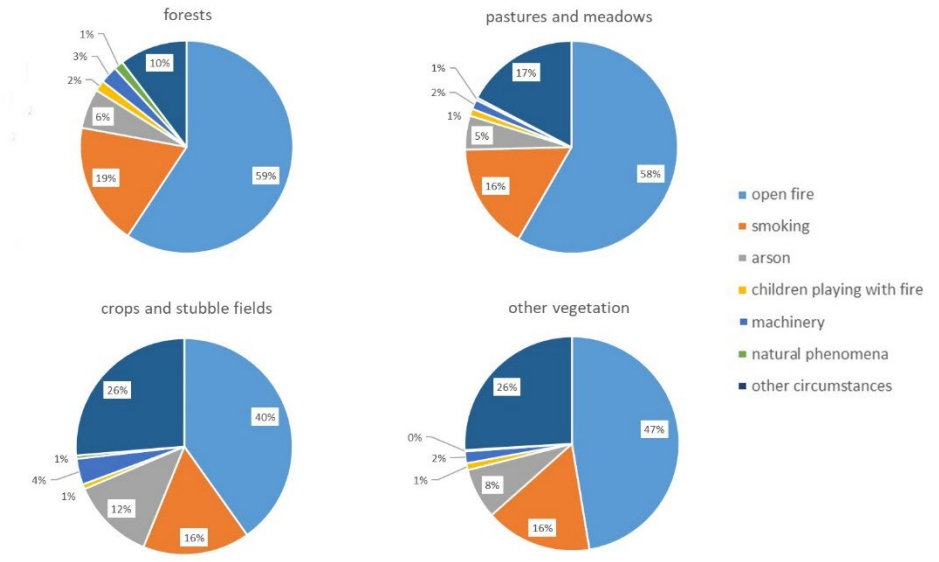

Fig. 3. Probable causes of fires on different types of vegetation (Data source: General Inspectorate for Emergency Situations)

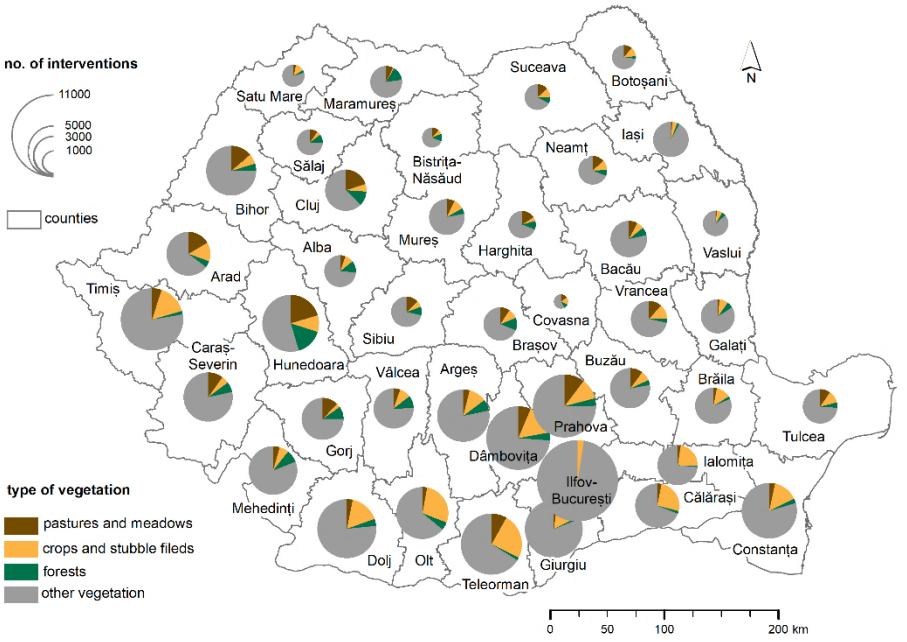

Fig. 4. Spatial distribution of the interventions by fire brigades on fires on various types of vegetation

Finally, when analyzing the spatial distribution of the interventions by fire brigades on vegetation fires (Fig. 4), one can observe of predominance of such events in the south-eastern part of the country. The highest number of vegetation fires occurred in the Ilfov county (11,108), followed by Dâmbovița (7275), Prahova (7131) and Timiș (7022).

The central, northern and eastern regions show much lower figures in terms of interventions of fire brigades upon vegetation fires. In fact, the counties with the lowest numbers of interventions were: Covasna (522), Bistrița-Năsăud (954), Satu Mare (1144), Botoșani (1323) and Vaslui (1475).

5. CONCLUSIONS

The increased frequency of vegetation fires in Romania is largely determined by the way the agricultural land is managed. Main causes include the deliberate burning of crops or stubble fields and pastures to clear them of unwanted vegetation or after crop harvesting. Therefore, further studies of vegetation fires at the national and regional level must pay special attention to this aspect.

Fires on agricultural land have an immediate, direct impact through the emission of greenhouse gases and of other elements contained in the smoke, and through other impacts upon the soil (Stan et al., 2014). However, these fires can also spread to other categories of land where they can cause significant damage or even victims (several press articles in the media describe dramatic effects of vegetation fires that have gotten out of control). Besides, according to Sbirnea and Mara (2021), at the national level, the most frequent cause of forest fires is fire extension from agricultural lands.

The UN (2021) proposes several alternatives to the practice of burning agricultural land. *Conservation agriculture* or permaculture and *no-till farming* are practices that aim to retain carbon in the soil and protect the soil from erosion. If the organic matter is removed from the soil, it can be used as *food for domestic animals* or as *bedding* in their shelters, or for the *production of bioenergy* (e.g., by producing pellets from agricultural and forestry residues and burning them in thermal power plants, by anaerobic digestion).

One can note that for some of the proposed alternatives, additional investments to carry out these processes and a market for the resulting products are necessary. Thus, given the fact that in Romania, most agricultural holdings are subsistence holdings, and the high average age of the rural population employed in agriculture, it may be unlikely that such alternatives will be implemented in the near future, on a large scale.

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