

# Rules for the construction of firebreaks along public roads in selected European countries

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## ABSTRACT

Firebreaks are one of the protective measures used to safeguard forests in case of fire. Their purpose is to limit the possibility of fire spreading. This article describes how these protective measures are implemented along public roads in selected European countries. Based on the information gathered, it was found that there is a wide variety of approaches to firebreaks' construction, mostly due to different climatic and geomorphological conditions that influence the overall risk of forest fires. The forms of firebreaks used in Europe along public roads are either a mineralised belt (without vegetation) or a cleared belt of materials that are particularly susceptible to ignition and fire spread. Methods combining both are also used.

In Poland, there is a Type A belt, that is, a 30-m-wide belt at the border of a roadway or a facility that is free of dead trees, lying branches and felled or broken trees. In the absence of pan-European rules on preventive measures to protect forests from road fires, it might be helpful to establish a set of best practices that could assist in the revision of guidelines in individual countries.

## KEY WORDS

fire, fire danger, forest, safety

## INTRODUCTION

Firebreaks are one of the protective measures used to safeguard forests in the event of fire. Their purpose is to limit the possibility of fire spreading. They are usually created in places where there is a risk of fire, for example, near communication routes, military training areas and industrial plants located in the forest or in its immediate vicinity. Belts are also used to divide large forest complexes into smaller ones, limit losses in large fires and create lines of defence during rescue operations.

At the beginning of the 20th century, firebreaks began to be established in Europe, initially along railway lines, which posed a high fire risk to forested areas. Subsequently, the principles for establishing belts along linear infrastructure changed. The first studies in Poland on firebreaks were conducted at the Forest Research Institute in the mid-1960s. This included work on modernising the belt system as part of the development of methods to prevent the spread of forest fires (Karlikowski and Łonkiewicz 1966) and on modifying the implementation of Kienitz belts along railway lines (Karlikowski and Łonkiewicz 1969). In the early 1970s,

an assessment of the usefulness of first- and second-order belts, carried out by Karlikowski and Łonkiewicz (1971) on the basis of several years of research, was of great practical importance. This proposed principles for the management of belts to make them an effective biological fire barrier through an appropriate selection of species, including biocoenotic admixtures, creating good living conditions for birds and animals and ensuring productive use of the area. Another evaluation of the effectiveness and extent of the use of firebreaks as a means of preventing the occurrence and spread of forest fires was presented in 1983 (Karlikowski et al. 1983). The study, which covered the years 1975–1982, showed that forest fires near public roads accounted for 24% of all fires and covered 18.6% of the total area burned. In contrast, fires near railway lines accounted for 17.2% (in terms of numbers) and 20.3% of the area burnt.

Currently, in Poland, according to the Regulation of the Minister of Internal Affairs and Administration of 7 June 2010 on Fire Protection of Buildings, Other Structures and Land (Journal of Laws No. 109, item 719), forests adjacent to facilities that may pose a fire risk to the forest are separated from these facilities by fire protection belts, which are maintained in a condition that ensures their year-round usability. The regulations of the Minister of Environment (Journal of Laws No. 58, item 405) and the Minister of Infrastructure (Journal of Laws 2020, item 1247) distinguish five types of firebreaks (types A, B, BK, C and D), which are established near public roads, railway lines, storage and public utility facilities, industrial facilities, military training areas and to separate large, dense forest areas. The obligation to create and maintain firebreaks lies with the land managers. In 2022, there were a total of 14,475 km of firebreaks in state forests, of which 77% were firebreaks next to public roads (7,621 km) and railway lines (3,550 km) (Wysocka 2023). The cost of maintaining belts next to public roads in state forests is almost 7.5 million zloty per year, while the losses caused by forest fires next to roads are estimated at tens of thousands of zloty.

Between 1981 and 1990, rail transport was the cause of 5.92% of forest fires and road transport was the cause of 0.56% of forest fire incidents in Poland. In the following decades, a decreasing trend of this phenomenon was observed, as between 1991 and 2000, 2.1% of fires occurred along railways and 0.48% along roads. In the

following decade, these were 0.81% and 0.34% of the total recorded forest fires, respectively (Szczygiel 2016).

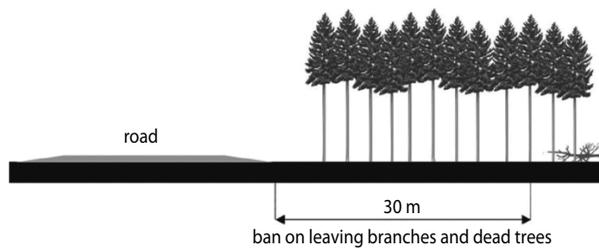
From time to time, the principles of maintaining fire belts need to be evaluated in terms of the suitability and effectiveness of this passive way of protecting forests from fires, analysing the changing factors that pose a threat while ensuring an optimal level of safety, also taking into account the economic calculation. The project commissioned by the General Directorate of the State Forests, entitled ‘Analysis of the Justification for the Establishment of Type A Firebreaks from a Safety and Economic Point of View’, examines whether it is justified to keep a belt adjacent to the boundary of a road lane devoid of dead tree parts. As a prelude to this assessment, a review of the principles of firebreaks adjacent to public roads in other European countries was carried out, the results of which are the subject of this paper.

#### **FORMAL REQUIREMENTS FOR THE ESTABLISHMENT OF TYPE A FIREBREAKS IN POLAND**

Under the current Polish law, forest managers are currently required to establish a Type A firebreak (Fig. 1). This is a 30-m-wide belt of land adjacent to the boundary of a road lane or facility and free of dead trees, lying branches and fallen trees (§ 10(1)(1) of the Regulation of the Minister of Environment of 22 March 2006 on the Detailed Principles of Forest Fire Protection; Journal of Laws of 2006, No. 58, item 405, as amended). Also, according to Section 39 (1) of the Regulation of the Minister of the Interior and Administration of 7 June 2010 on the Fire Protection of Buildings, Other Structures and Land (Journal of Laws of 2010, No. 109, item 719), it is prohibited to deposit, in particular, branches, brushwood, unkempt felled trees and post-mining waste at a distance of less than 30 m from the edge of a railway track or a public road, with the exception of roads with an unpaved surface. The deposit of these residues in the form of banks and heaps is not permitted. The Type A belt separates the forest from public roads, access roads that are not public roads – from an industrial or storage facility, storage facilities and public utilities. The vast majority of these belts are realized by the forest department. According to the provision of section 38(3) of the above-mentioned regulation, if a forest area:

- is classified as Category III forest fire danger,
- stands older than 30 years and is located along public roads and car parks,
- has tree stands located along roads with unpaved surface, with the exception of military training grounds and between military training grounds and
- is less than 200 m wide,
- there is no obligation to create Type A firebreaks.

It should be noted that forest owners, managers or users whose forests alone or together form a forest complex of more than 300 ha are obliged to maintain firebreaks.



**Figure 1.** Type A firebreaks (Manual... 2020)

## OVERVIEW OF THE RULES FOR ROADSIDE FIREBREAKS IN EUROPEAN COUNTRIES

No information was found in the literature on regulations for the creation of firebreaks along public roads in European countries. There are also no European Union (EU) directives in this area, and knowledge about the requirements for the installation of firebreaks is not widespread. For this reason, individual European countries were asked to indicate the applicable standards for the installation of firebreaks along public roads. The range of information received is not uniform and is partly due to the fact that each country has a different emphasis on the issue of protecting forests from fires along public roads. Guidelines for the establishment of firebreaks in selected countries are presented below.

### Bulgaria

Mineralised belts 1.5–3 m wide are laid out along public roads and railway lines. In areas adjacent to forest and pastureland, the width of the belts is doubled. Belts are also established around car parks and recreational areas. The width of the mineralised belts is adapted to the

existing fire hazard as well as to the degree of anthropogenic pressure.

In addition, it is possible to establish sanitary belts where the forest borders roads or railway lines. These are areas cleared of dry biomass (fallen trees and other plant debris). The width of the sanitary belts shall not be less than 10 m. The need for sanitary belts in combination with mineralised belts is determined by a fire risk assessment, which is the responsibility of forest managers.

According to the Forest Act, forest owners are obliged to implement planned treatments to reduce the risk of forest fires. These treatments are approved in forest management plans or forest management programmes according to Bulgarian legislation.

### Lithuania

The current forest fire protection regulations take into account the requirements for firebreaks. According to these, mineralised firebreaks are created next to roads at a distance of 2–5 m from the roadside, behind which belts of conifers or deciduous trees of width 10–20 m are created. In 2021, 12,167.4 km of firebreaks was mineralised. It is worth noting that the obligation to create firebreaks along roads is not mandatory.

### Latvia

According to the 2016 legal regulations on firebreaks along national and municipal roads, the road manager (State Highways and local government roads) is required to maintain a ditch and a belt of width 1.5 m and free of trees and shrubs. The road manager is obliged to mow the ditches and belts next to the roads. In Latvia, there are no regulations for roads that pass through forest areas. The State Forestry Agency in Latvia has issued internal regulations stating that the maximum width of the roadway, including the ditch and the belt free of shrubs and trees, is 30 m.

### France

Firebreaks are created along public roads. Their width varies and depends on the type of road and the region of the country. The methods of maintaining firebreaks also vary and depend on the region. However, the basic rule is that herbaceous vegetation, low shrubs and dead trees on both sides of the road must be removed. The maintenance of firebreaks is the responsibility of the public administration.

The French Forest Code prescribes clearing of the immediate vicinity of public roads to prevent forest fires. Article L.134-10 of the Forest Code states that the managers of public roads must clear the vicinity of roads with a width of 20 m or less on both sides of the carriageway. It is up to the authorities of each region to determine this width and the methods for clearing the forest areas adjacent to the roads. This provision applies to roads that cross forest areas or are less than 200 m from forests. The regulations only apply to the regions with high fire risk. A large part of these is in the southern part of France. Depending on the department and the type of public roads (motorways, national roads, regional roads, municipal roads), the width of the carriageways varies, as shown in Table 1. Some departments also specify a minimum distance (width and height) above the carriageway that must be free of branches, which is usually an area of about  $4 \times 4$  m.

It should be noted that each road manager has the opportunity to submit his/her study on the design and

maintenance of firebreaks and to make proposals for alternative clearance of the area next to the road and other proposals on the width of the carriageway. These changes must ensure the safety of people and goods with the same efficiency as guaranteed by the general regulations in the region. The departmental authorities may accept or reject the road manager's study.

### Portugal

Legislation requires road managers to clear vegetation in a 10-m belt along each side of the road. This width can be increased or decreased by 5 m depending on the local fire risk. The duty to maintain firebreaks applies to most, but not all, public roads, as roads must be identified as important in local fire safety plans. The road managers are mainly the 'Central State Public Company' (*Infraestruturas de Portugal*) and the municipalities.

It is considered that 10 m belts along roads allow firefighting units to contain low- and medium-intensity fires. However, their main function is not so much

**Table 1.** Width of firebreak in different regions of France by road category and definition of the width and height of the space above the carriageway

Region	Highways	National roads	Regional roads	Communal roads	Width $\times$ height of space above road
Alpes de Haute Provence	Width depending on the risk level (15–20 m)			5 m	$4 \times 4$
Hautes Alpes	10 m	3 m		2 m	$5 \times 4$
Alpes Maritimes	6–20 m depending on the municipality				Not specified
Bouches-du-Rhône	20 m			10 m	$4 \times 4$
Var	Very high risk: 20 m High risk: 10 m Medium risk: 3 m	20 m	10 m, but may be increased to 50 or 100 m, on for some strategic roads, decision taken by the Regional Council	2 m	$4 \times 4$
Vaucluse	Very high risk: 20 m High risk: 10 m Medium risk: 3 m			Very high risk: 10 m High risk: 5 m Medium risk: 3 m	$3.5 \times 3.5$
Gard	10 m				Not specified
Hérault	5 m				$4 \times 4$
Lozère	4 m				Not specified
Aude	20 m for main roads, 2 m for other roads				Not specified
Pyrénées-Orientales	0–20 m depending on the information provided by the road owner/manager				Not specified
Drôme	3 m			0	Not specified
Ardèche	2 m				Not specified
Corse-du-Sud	Roadside only (a few metres)				$4 \times 4$
Haute-Corse	Roadside only (a few metres)				$4 \times 5$

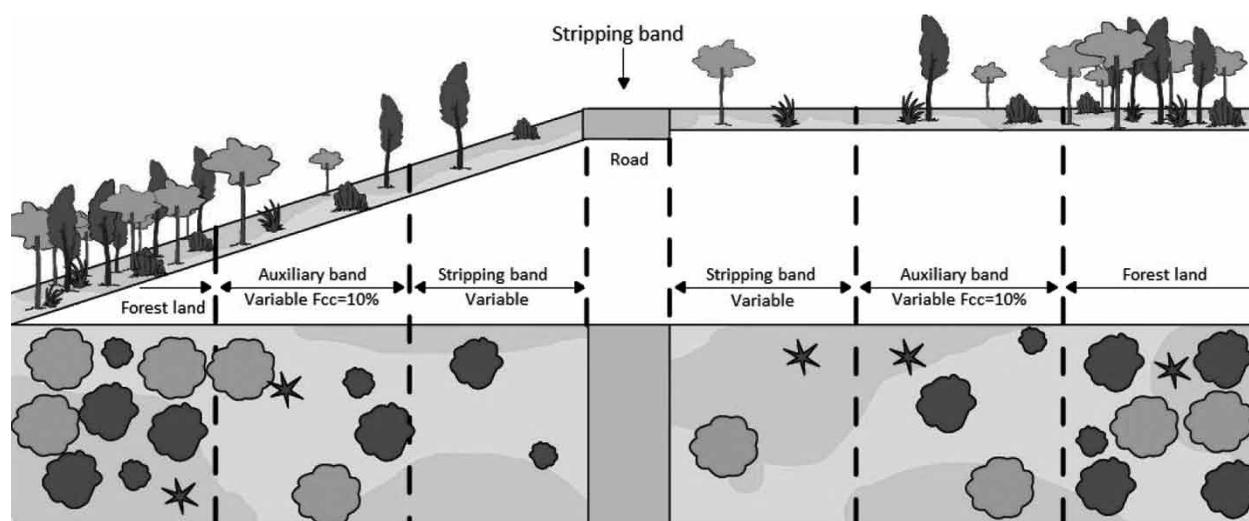
to stop the spread of fire from one side of the road to the other, but primarily to protect people who might use the roads in the event of a fire. In 2017, there were incidents in Portugal in which several people died because they were trapped on the road through which a fire was moving.

The legal act ‘Measures and Actions to be Applied in the National Forest Fire Protection System’ (Decree-Law No. 124/2006 Medidas e acções a desenvolver no âmbito do Sistema Nacional de Defesa da Floresta contra Incêndios, Decreto-Lei n.º 124/2006 – Diário da República n.º 123/2006, Série I-A de 2006-06-28) contains guidelines on the structure of the stand and the treatments to be applied when the fire belt is established. They state the following:

- in a stand, the distance between crowns must be at least 10 m;
  - in pine and eucalyptus stands, branches must be pruned to 50% of the tree’s height until they reach a height of 8 m; thereafter, pruning is limited to at least 4 m above the ground;
  - in other tree species, the permissible distance between crowns must be at least 4 m and pruning must be 50% of the tree height up to a height of 8 m, after which pruning is limited to at least 4 m above the ground;
  - in the shrub layer, the maximum height of vegetation shall not exceed 50 cm;
  - in the undergrowth layer (under shrubs), the maximum height of vegetation shall not exceed 20 cm;
- in the case of road network infrastructure adjacent to particularly valuable natural, landscape and cultural stands, the firebreak should be at least 10 m wide on each side, plus a width corresponding to the vertical projection of the tree crown;
  - all accumulated flammable substances, such as firewood, biomass resulting from stand maintenance or agricultural work and other highly flammable materials must be removed;
  - in the case of firebreaks for the protection of trees of natural, cultural or landscape value, groups of trees and other vegetation protected under nature conservation and biodiversity protection and identified, inter alia, in forest management documents or other site management documents, for example, Natura 2000; the local forestry authority may approve additional criteria for the establishment and maintenance of firebreaks at such sites and
  - treatments on firebreaks must be carried out by 30 April each year.

### Spain

In this country, there is no clear national legislation on firebreaks along roads. Spain is divided into 17 autonomous regions, each of which implements measures to protect against forest fires. In the Valencia region, for example, there are three types of recommendations on fire protection, dealing with the following issues: forest roads, water points and technical regulations for the division of the forest area, so that firefighting



**Figure 2.** Scheme for the creation of firebreaks near roads using the example of the Valencia region (after Baixauli et al. 2015)

is possible (Baixauli et al., 2015). The last document describes in detail the firebreaks that are created on the forest plots. Their density and arrangement depend on the size of the forest complex, the terrain and other factors. The measures taken consist of creating a firebreak in which the vegetation is removed over a certain width down to the mineral layer. From this belt, intensive vegetation reduction is carried out on two sides, gradually decreasing as the distance from the mineral belt increases. For forest roads and public roads, the same type of firebreaks applies, as shown in Figure 2 (Baixauli et al. 2015).

### Ukraine

According to the Resolution of the Council of Ministers of Ukraine (dated 20 May 2022, No. 612 Kyiv) 'Procedure for organising forest protection', road administrators are obliged to reduce the risk of fire in areas adjacent to forests. The law states that authorities responsible for roads whose carriageway borders forest areas are obliged to ensure the following:

- 1) clear the roadway of vegetation and objects that could create or increase a fire danger and
- 2) carry out fire safety monitoring along the roadway during times of fire danger and respond immediately if a fire is detected.

The establishment of firebreaks is included in the Fire Protection Project for each forest area. The projects are prepared every 10 years in consultation with local forest districts to optimise the need for establishing firebreaks near roads. The number and type of firebreaks are determined in the project, which also takes into account the following:

- degree of fire danger, terrain characteristics, hydrography of the area, presence of possible fire sources, number of fires;
- the presence of natural fire barriers: rivers, lakes, wetlands, stands with predominantly deciduous tree species and
- the general extent of forest management and anthropogenic pressure.

In Ukraine, different types of barriers are used along roads to contain fires. The most important of them is firebreaks, which are characterised by the removal of vegetation down to the mineral layer. Their width should be twice the possible flame height during a fire, but not less than 2.8 m. Such belts can be

a stand-alone barrier to fire spread or part of a wider fire barrier.

Additional measures that can be implemented along roads include the following:

- crown pruning to a height of 2 m,
- creating wide tree- and shrub-free belts, 50–150 m wide, with a central road to prevent wildfires,
- creating biological belts of deciduous tree species near pine stands and
- creating technical corridors in forest areas and in forest complexes next to public roads, which increase the chances of stopping a fire and improve the spatial conditions for fire-fighting vehicles.

### United Kingdom

There is a guide, 'Building wildfire resilience into forest management planning', published by the Nationwide Forestry Commission in 2014. The guide does not provide explicit guidance on establishing firebreaks along roads. The document recommends increasing forest fire resilience along roads by removing dead organic material that could fuel a surface fire. It is recommended that a so-called 'firebreak' be maintained without woody and bushy vegetation. In the stand, it is recommended that the belt is one-stand-height wide. For sites with a higher fire risk, three times the width of the height of the adjacent vegetation is recommended. The guidance does not include information on the maintenance of mineralised belts (also without grass vegetation).

It was pointed out that the so-called 'firebreaks' should, as far as the terrain allows, be accessible to vehicles involved in firefighting and their width should not be less than 3 m. The guide also includes advice on how to manage the forest in a way that reduces the risk of fire in the forest, for example, through biodiversity in restored areas.

### Romania

There are regulations to protect against forest fires in connection with the linear infrastructure passing through these areas. In Ministry of Agriculture, Forestry and Rural Development Regulation No. 551/2006, which adopted the Regulation on the Management of Emergency Situations Resulting from Forest Fires, there is a provision stating that isolation belts must be placed on the sides of roads, highways and railway lines

that pass through forests. Isolation belts are understood to mean the removal of combustible material (dry grass vegetation, rubbish) over a width of 5–10 m. The regulations do not explicitly state what the width of the belt depends on. Grasses are removed by mowing. There is no requirement to remove trees and shrubs from the isolation belt. The same provision is also found in the Regulation of the Minister of Environment No. 1654/2000 on the Approval of Standards for the Prevention and Extinguishing of Fires in Forest Areas. The forest districts are responsible for the maintenance and execution of the belts.

In 2019, questionnaires were sent to district emergency inspectorates, in which one of the questions concerned the maintenance of isolation belts along transport infrastructure that passes through forest areas. The responses received indicated that the maintenance of isolation belts by the forestry department is not adequate, and that the provisions of the regulation are not always complied with.

#### **Germany**

Narrow (1–2 m) mineralised belts next to public roads are used. Their establishment is not obligatory in all federal states that implement individual forest fire protection measures. The costs of maintaining the belts are borne by the forest owner. Currently, roadside fires are not very frequent in Germany.

#### **Italy**

There are no explicit regulations for firebreaks along roads. In the Encyclopedia of Wildfires and Wildland–Urban Interface (WUI) Fires, the article Firebreak and Fuelbreak by Ascoli et al. (2018), among others, provides guidelines for establishing firebreaks along linear infrastructure. It is recommended to reduce the number of trees near roads; there is no information on how far from the road such an area should be maintained, but it is recommended to maintain a ‘fuel-free’ area, that is, without trees and shrubs, in a zone between 2 and 5 m. It is also recommended that the crown height should be over 3 m from the road.

Firebreaks along Italian roads are often difficult to implement because some of the roads pass through mountainous terrain where the slopes of the roads are protected by concrete barriers, among other things, to limit rockfall onto the roadway.

#### **Hungary**

A 2-m-wide firebreak must be maintained along roads and railway lines adjacent to forest areas. The operators of public roads or railway lines are obliged to maintain the firebreak. The roadway must be kept clear of branches, bushes, shrubs and trees. The problem with maintaining a firebreak along roads is that sometimes, there is no space for a 2-m-wide firebreak along a road due to the terrain (mountains, highlands, rocky ground). Sometimes, firebreaks next to roads are not maintained at all by land managers because the government does not provide funds for this purpose. Maintenance of the belts is controlled by the fire brigade, which does not impose penalties if the belts are not maintained.

#### **Switzerland**

There are no guidelines or rules for creating firebreaks next to roads. In selected regions identified as fire-prone areas, dead biomass is removed (up to about 10 m from the road) to reduce the risk of fire spread. Such measures are taken, for example, in southern Switzerland, the most fire-prone region in the country.

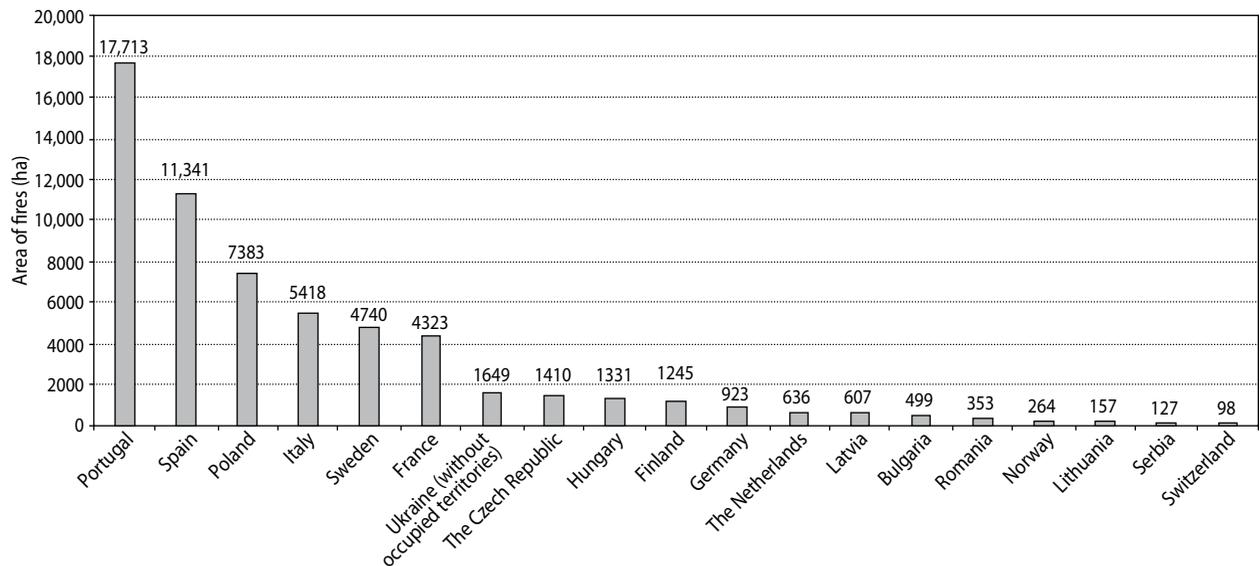
According to the information received, the absence of firebreaks along roads does not currently contribute to the risk of forest fires. Switzerland is a country with few fires compared to Polish conditions. Between 2011 and 2020, there were more than 100 fires per year in only 4 years.

#### **The Czech Republic, Finland, the Netherlands, Norway, Sweden and Serbia**

In these countries, due to the low fire risk along public roads, no special maintenance of firebreaks along road infrastructure is carried out. In some of these countries, this is due to the mountainous terrain, technical difficulties in creating and maintaining firebreaks along roads or the high fragmentation of forest ownership.

#### **SUMMARY**

Twenty-one European countries were asked to provide information on the rules for creating and maintaining firebreaks along public roads, primarily using contacts with national representatives who are members of the EU Expert Commission on Forest Fires. Countries



**Figure 3.** Average annual number of forest fires in selected European countries between 2011 and 2020 (excluding the UK [data not available]) (based on the report San-Miguel-Ayanz J. et al. 2022)

where forest fire risk is minimal were omitted. Feedback was received from 19 countries.

The information provided shows that these countries approach the fire protection of forests along public roads in different ways, mainly due to the fire risk assessment along roads crossing forest complexes and the general forest fire risk in the respective country. Figure 3 shows the average annual number of forest fires that occurred between 2011 and 2020 in the countries that responded to the question about firebreaks along public roads. The data was compiled based on the European Forest Fire Information System (EFFIS).

In six countries (the Czech Republic, Finland, the Netherlands, Norway, Serbia and Sweden), belts along roads in forest complexes are not established at all due to lack of danger. In the remaining 13 countries, belts are established either in the form of a mineralised belt or a cleared belt of materials particularly susceptible to ignition and fire, or methods combining both are used.

The essence of creating a mineralised furrow is to create a barrier that is completely free of combustible material to prevent the spread of fire. Its effectiveness depends primarily on the width of the mineralised furrow and the burning intensity of the materials in front of the furrow, as well as on the height of the fire zone, which is influenced by the type of vegetation and mete-

orological conditions. Therefore, such a belt should be established as close as possible to the edge of the path to prevent intense burning, which increases the risk of fire metastasis beyond the mineralised belt. In general, the lower the amount of combustible material in front of the firebreak (e.g. due to mowing of the roadside) and the greater the width of the furrow, the greater the barrier effect of the belt for a fire in the germination phase. If there is tall grass and shrub vegetation, especially dry vegetation, both in front of and behind the mineralised barrier, it will not be an effective barrier in the event of a developing fire even if the ground is free of vegetation over a width of several metres. This is illustrated by the examples of large-scale forest fires in Poland in Kuźnia Raciborska (approx. 9,000 ha) (Jopek 2016) and Potrzebowice (5,600 ha) in 1992 (Szczygiel 2016), when mineralised belts of 2 m width were not able to contain a developed fire that had started next to a railway embankment about a few metres from the mineralised belt at both sites.

On the other hand, the establishment of firebreaks in the form of cleared land of combustible material that could potentially pose a hazard (e.g. undergrowth, brush, undergrowth, lying branches, tall herbaceous vegetation, etc.) is intended to limit the speed of fire spread and its intensity. This is due to the limited amount of combustible material. These belts are wider

than the mineralised belts and vary in size from a few metres to several tens of metres.

Simple mineralisation belts are established in Lithuania, Ukraine, Germany, Romania and Bulgaria, among others, and their width varies between 1 and 6 m. The relatively small number of countries ordering only this type of protection may be due to the low evaluation of the effectiveness of mineralisation belts and also the difficulties and costs of mineralisation on site. In nine countries (Bulgaria, Latvia, France, Portugal, England, Romania, Italy, Switzerland and Ukraine), belts are established in the form of a cleared area next to a public road running through or in the immediate vicinity of a forest. The width of the cleared belt varies and ranges from 2 m (Italy) to 30 m (France). The most detailed regulations for clearing belts are in France and Portugal, where their implementation is based on the local fire risk and the type of road (motorway, national road, municipal road, which should be understood as traffic volume) or its importance in the forest fire protection system of the area, as defined in the fire protection plan (Portugal). In Spain, firebreaks are established not only along public roads and forest roads, but also, depending on the size of the complex, in compact complexes that are not crossed by roads. These are the countries with the highest forest fire risk, which is also shown in Figure 3. In England, the width of the cleared belt depends on the height of the stand and can be up to three times the height of the adjacent vegetation in areas of increased risk. Only in two countries (Bulgaria and Ukraine) are both mineralised and cleared belts of combustible forest fuel established along roads. Firebreaks in the form of cleared flammable forest material are also important from the point of view of organising firefighting operations, as they can facilitate the deployment of firefighting units to prevent the fire from spreading to the other side of the road in the case of low- and medium-intensity fires that spread from deep in the forest, which can also pose a risk to road traffic (Portugal). The obligation to establish both types of firebreaks lies with the manager of the forest (Bulgaria, Lithuania, Romania, Germany) or the road (Latvia, France, Portugal, Ukraine, Hungary). The establishment of a firebreak alone does not guarantee that it will effectively contain a forest fire. For it to be effective, it must be properly maintained, especially during the period of fire danger. As a result, fires sometimes pass

through poorly maintained belts because they do not provide a barrier, for example, due to the emergence of tall herbaceous vegetation, which facilitates the spread of fire.

There are no publications in the available literature evaluating the effectiveness of firebreaks as a means of preventing the spread of fires along road or rail routes. National studies state that the average area of a fire along public roads in Poland between 1975 and 1982 was 1.34 ha, while between 1990 and 2002, it was 0.36 ha (Piwnicki et al. 2006). According to a detailed study, fires on firebreaks next to public roads accounted for 0.92% of the total number of forest fires in 2003–2004 (there were 24,093 of them) and their average area was 0.26 ha. At that time, as in previous years, there was an obligation to create a mineralised furrow on the edge of public roads, in addition to clearing the areas, with a minimum width of 2 m at a distance of 2–5 m from the outer edge of the road ditch. Only 60% of the fires broke out in front of the furrow (i.e. it could serve as a barrier to the spread of fire from the outset), but unfortunately, almost half of the fires penetrated through the mineralised zone. This was an indication of the low effectiveness of the mineralised furrow, which could also be due to negligence in the construction of the lane or poor maintenance. This led to a change in legislation and the abandonment of mineralisation of forest soils next to public roads, which was costly and did not guarantee an adequate level of safety (Piwnicki et al. 2006).

Between 2017 and 2021, 11,106 fires were recorded in the national forests, with a burnt area of 3,780 ha. Of these, 768 occurred near public roads, where an area of 55 ha was destroyed. The average area burnt in forests was 0.34 ha, next to roads (0.07 ha). These were mostly fires of ground cover (92%), caused by ignition of the fire, noticed by bystanders (70%) and extinguished quickly (in 77% of the incidents, the fire brigade's intervention time was no more than 90 min) (Szczygieł et al. 2022). The significant decrease in roadside fires can be attributed to the increase in the effectiveness of the fire protection system in state forests and the development of mobile network communication, which makes it possible to quickly report fires noticed by bystanders.

In the absence of Europe-wide regulations on prevention measures to protect forests from road fires, it may be helpful to establish a set of best practices that

could be used to amend existing policies in individual countries where means of transport pose a fire risk. However, it is advisable that each country addresses this issue individually, taking particular account of natural and landscape conditions, to best protect natural assets and minimise economic losses.

In Poland, the current requirement to keep a space 30 m from the roadway free of dead plant parts is one of the strictest. In the information provided from other countries, there is more than one reference to keeping, for example, a belt free of woody and shrubby vegetation at a distance from the carriageway, which is not taken into account in the Polish regulations. Other countries also take into account the areas of mowed ditches, the branch-free space above and beside the lane. A review of data on the methods of protecting forest areas next to public roads in selected European countries and a national analysis of the occurrence of fires in their vicinity lead us to take a critical look at our current regulations in this area, not only in terms of ensuring adequate forest fire protection, but also taking into account the economic calculation of establishing Type A firebreaks in their current form.

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