Developments in Environmental Science, Volume 8
A. Bytnerowicz, M. Arbaugh, A. Riebau and C. Andersen (Editors)

ISSN: 1474-8177/DOI:10.1016/S1474-8177(08)00010-7

Chapter 10

Spatial and Temporal Trends in Distribution of Forest Fires in Central and Eastern Europe

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Abstract

Forest in Central and Eastern Europe (CEE) covers 56,285,000 ha (5% of European total forested area). Forest cover in CEE makes 30% of land use. Almost 50% of the forest under study is formed by coniferous species and only 30% by deciduous ones. Forest younger than 60 years old grows on 57% of that area. These factors, together with climate conditions cause that on the main part of CEE middle forest fire risk is noted. Between 1991 and 2001 some 387,680 fires burning 757,000 ha were noted in CEE. The most hazardous situation is observed in Poland where over 60% of fires and burns happen. Forest Research Institute in Warsaw has prepared a method of emission calculation based on the Polish experience. As the type of forest and environmental condition in the described area are similar, some calculations on emissions from neighbor countries, based on FAO's forest fire statistics were elaborated.

10.1. Characteristics of Central and Eastern European forests

For the purpose of this chapter the central and eastern European (CEE) countries are Austria, Belarus, Czech Republic, Estonia, Germany, Hungary, Latvia, Lithuania, Poland, Slovakia, and Ukraine (Fig. 10.1). Forests in CEE cover 56,285,000 ha (UNEP/FAO, 2000), which is about 5% of Europe's forested areas. Forestation of this part of the continent reaches 30% (it is about 46% on average throughout Europe).

Three types of temperate forest are the most common in the CEE countries: oceanic, continental, and mountain (UNEP/FAO, 2000).

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Figure 10.1. Central and eastern European countries.

Temperate oceanic forest is dominant in Germany (with the exception of a main part of the Land of Brandenburg) and northwestern Poland. Various types of European beech forests (*Fagus silvatica*) and its mixture are common here. However, large areas have been reforested with Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris* L.). Apart from the mentioned species, the oak-ash (*Quercus* sp., *Fraxinus excelsior*) and oak-hornbeam (*Quercus* sp., *Carpinus betulus*) forests are also dominating locally. Temperate continental forests in CEE countries consist of Scots pine, Norway spruce, as well as oak-hornbeam and lime-oak (*Quercus* sp., *Tilia cordata*), while on permanently wet sites, black alder (*Alnus glutinosa*), and common ash (*Fraxinus excelsior*) appear. Temperate mountain forests formed by common beech, silver fir (*Abies alba*), and Norway spruce are not very sensitive to fire due to their specific climatic conditions (high precipitation and low temperature). In the CEE area the share of predominantly coniferous forest has been increasing over the past two centuries as a result of management practices oriented toward maximization of lumber production. Recently, this trend has

slowed down; however, only in Hungary, Slovakia, and the Ukraine broad-leaved species predominate (UNEP/FAO, 2000).

In Austria 88% of the forest area is coniferous or mixed coniferous/broad-leaved; in Germany 50% of the forest area is coniferous and 20% is mixed coniferous/broad-leaved; while in Poland and Belarus these values are respectively 30%, 20%, and 40%. In the Czech Republic more than 50% of forest area is covered by mixed coniferous/broad-leaved, but as much as 80% of growing stock is coniferous (UNEP/FAO, 2000). Forest expansion is observed in Germany, Poland, Slovakia, Ukraine, and Belarus as a result of afforestation and conversion of other land to forest, as well as due to preservation of soil against erosion. The highest rate of forestation is over 45% and found in the CEE countries of Estonia, Latvia, Austria, Belarus, and Slovakia, and the lowest is less than 20% and found in Ukraine and Hungary (Table 10.1). The pattern of forest ownership varies from country to country as a result of historical, political, and social influences. Countries where the state owns the major share of forests are Baltic countries and Poland (81%), the Czech Republic (71%), Hungary (63%), Slovakia (43%), and Germany (33%).

10.2. Presence of forest fires in CEE

The forests in CEE should be classified as exposed to medium fire danger, with the exception of certain parts of Poland and eastern Germany, which are characterized by a potentially high risk of fire outbreaks.

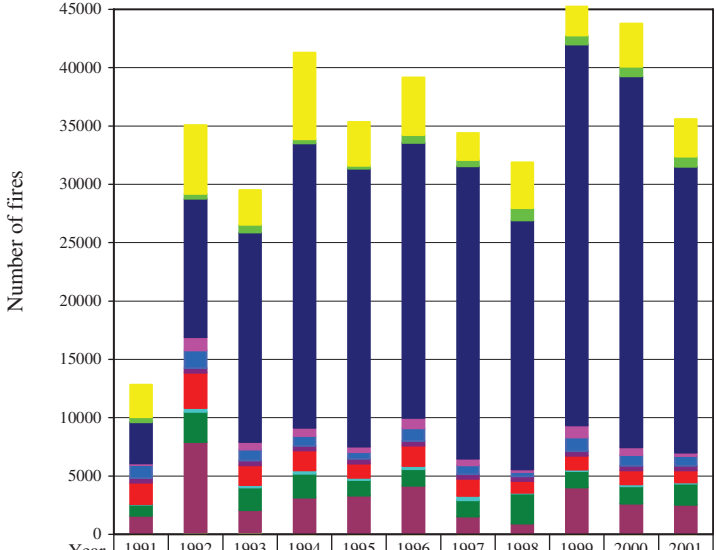
Table 10.1. Forest area and volume in CEE countries (UNEP/FAO, 2000)

Country	Country area	Forested area		Volume and biomass	
	k ha		%	$m^3\,ha^{-1}$	$t\,ha^{-1}$
Austria	8273	3886	47.0	286	250
Belarus	20,748	9402	45.3	153	80
Czech Republic	7728	2632	34.1	260	125
Estonia	4227	2060	48.7	156	85
Germany	34,927	10,740	30.1	268	134
Hungary	9234	1840	19.9	174	112
Latvia	6205	2923	47.1	174	93
Lithuania	6258	1994	31.9	183	99
Poland	30,442	9047	29.7	213	94
Slovakia	4808	2177	45.3	253	142
Ukraine	57,935	9584	16.5	179	87[a]

[a]Assumed as mean value calculated from forest areas of Belarus and Poland.

Primarily, this risk is caused by the domination of coniferous stands, representing 57% of the surface area of forests. Contribution of mixed and broad-leaved forests is 30% and 13%, respectively. Moreover, 65% of forests are younger than 60 years, which causes them to be especially subject to initiating and spreading fires (FAO, 2001; UNEP/FAO, 2000).

Between 1991 and 2001, 387,680 forest fires occurred in CEE (Fig. 10.2, Table 10.2). As a result of these fires 757,071 ha forests and barren land burned down (Fig. 10.3, Table 10.3) (FAO, 2001), which comprised 37% of the total number of fires in Europe and 13% of the burned area.



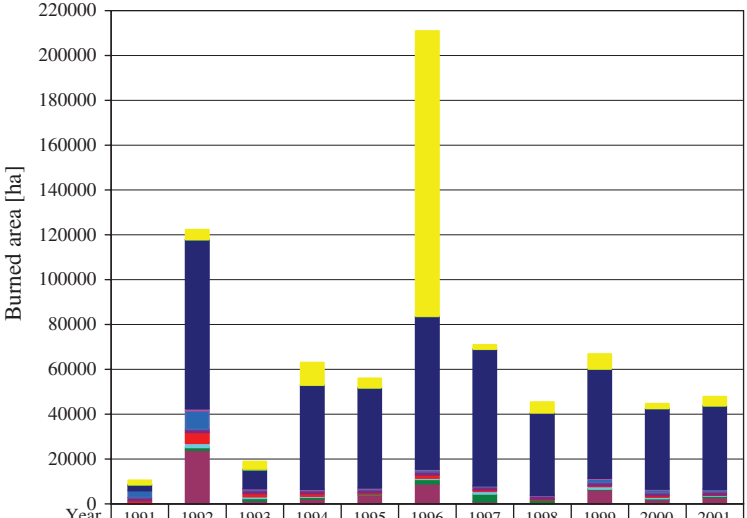
Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Ukraine	2771	5869	2967	7411	3754	4928	2309	3915	6070	3696	3205
Slovakia	431	431	674	366	254	662	535	1056	751	824	877
Poland*	3528	11,858	17,961	24,372	23,821	23,588	25,070	21,346	32,649	31,812	24,513
Lithuania	147	1154	635	714	472	889	565	231	1022	654	287
Latvia	1110	1510	965	854	582	1095	768	357	1196	915	823
Hungary	393	393	393	393	393	393	393	393	393	393	393
Germany	1846	3012	1694	1696	1237	1748	1467	1032	1178	1210	1032
Estonia	39	348	207	289	188	273	359	61	130	158	116
Czech Republic	961	2586	1951	2052	1331	1421	1398	2563	1403	1499	1822
Belarus	1517	7743	1887	3052	3257	4123	1466	876	3959	2569	2468
Austria	78	165	178	94	64	41	66	57	57	57	57

* In 1991—1993 without the wildland fires.

Figure 10.2. Number of forest and wildland fires in CEE countries in 1991–2001 (FAO, 2001, Forestry, 1991–2001, UNEP/FAO, 2002).

Table 10.2. Numbers of forest and wildland fires for Europe and only the CEE countries in 1991–2001 (FAO, 2001; Forestry, 1991–2001; UNEP/FAO, 2002)

Area	Years											
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	1990–2001
CEE countries	12,821	35,069	29,512	41,293	35,353	39,161	34,396	31,887	48,808	43,787	35,593	387,680
Europe	56,490	79,058	69,588	77,771	85,107	87,580	92,526	120,742	118,263	140,316	106,692	1,034,133



Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Ukraine	1781	4252	3214	10,040	3995	127,061	1835	4706	6494	1905	3860
Slovakia	233	233	518	96	85	220	35	32	96	105	78
Poland*	2567	75321	8290	46,379	44,681	68,039	60,967	36,814	48,687	35,956	37,386
Lithuania	54	863	305	301	321	385	139	93	494	352	112
Latvia	3096	8366	510	350	536	927	390	211	1544	1341	1032
Hungary	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349
Germany	920	4908	1493	1114	592	1381	599	397	415	581	122
Estonia	58	1787	647	456	158	528	1114	54	1103	684	314
Czech Republic	76	1278	1151	808	403	2043	3475	1132	336	375	614
Belarus	319	23,822	1253	2105	3780	8952	965	547	6261	1931	2913
Austria	53	132	112	57	32	28	39	33	33	33	33

* In 1991 and 1993 without wildland fires. In 1992 with peat burns (31,566 ha).

Figure 10.3. Forest and wildland burned areas in CEE countries in 1991–2001 (FAO, 2001, Forestry, 1991–2001, UNEP/FAO, 2002).

Table 10.3. Forest and wildland burned area ha in entire Europe and in CEE countries in 1991–2001 (FAO, 2001; Forestry, 1991–2001; UNEP/FAO, 2002)

Area	Years											
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	1991–2001
CEE countries	10,506	122,311	18,842	63,055	55,932	210,913	70,907	45,368	66,812	44,612	47,813	757,071
Europe	585,774	462,100	488,236	804,814	435,517	296,510	364,824	707,920	362,704	928,416	463,186	5,900,001

Majority of fires (over 60% of all fires registered in CEE) were in Poland, where 240,518 fires burned 465,087 ha (FAO, 2001; Forestry, 1991–2001; UNEP/FAO, 2002). Other countries highly threatened by fires were Ukraine (46,895 fires on the area of 169,143 ha in the analyzed period), Belarus (32,917 fires, 52,848 ha), Czech Republic (18,987 fires, 11,691 ha), and Germany (17,152 fires, 11,691 ha) (FAO, 2001; UNEP/FAO, 2002). Austria and Estonia were much less affected by forest fires (FAO, 2001; UNEP/FAO, 2002).

The largest number of fires in all countries occurred in 1999 (48,808 fires), in 2000 (43,787), and in 1994 (41,293) (FAO, 2001; Forestry, 1991–2001; UNEP/FAO, 2002). However, the largest burned area was in 1996, when 210,913 ha were affected by fires (with the main contribution of burned area in Ukraine) and in 1992 (122,311 ha) when a disastrous fire situation occurred in Poland (FAO, 2001; Forestry, 1991–2001; UNEP/FAO, 2002). Mean annual number of forest fires and the area burned by fires between 1991 and 2001 normalized to 10,000 ha of forest area is presented in Fig. 10.4. This objective index of fire and burned area density supports results of the fire occurrence statistics, showing that in Poland that index reached the highest values (24.17 fires and 46.73 ha of burned area). Other countries had much lower values of the fire density index, and among them the highest were Czech Republic (6.56), Ukraine (4.45), Belarus (2.18), and Latvia (3.16). However, while considering the burned area index, the sequence is slightly different and Poland is followed by Ukraine (16.04 ha), Hungary (7.33 ha), Latvia (5.69 ha), and Belarus (5.11 ha).

Every year the forest fires cause enormous economic losses, but their ecological damages are even more severe. Emission of gases and particles transported with smoke to the atmosphere, which contribute to the greenhouse effect, is one of the main impacts of fires on the natural environment. Emissions from burning biomass of boreal forests reach 3–5% of the total annual world value (Goldammer & Furayev, 1996). These emissions do not only contribute to the greenhouse effect and acid rain but also produce smoke aerosols, increasing the reflection of sun

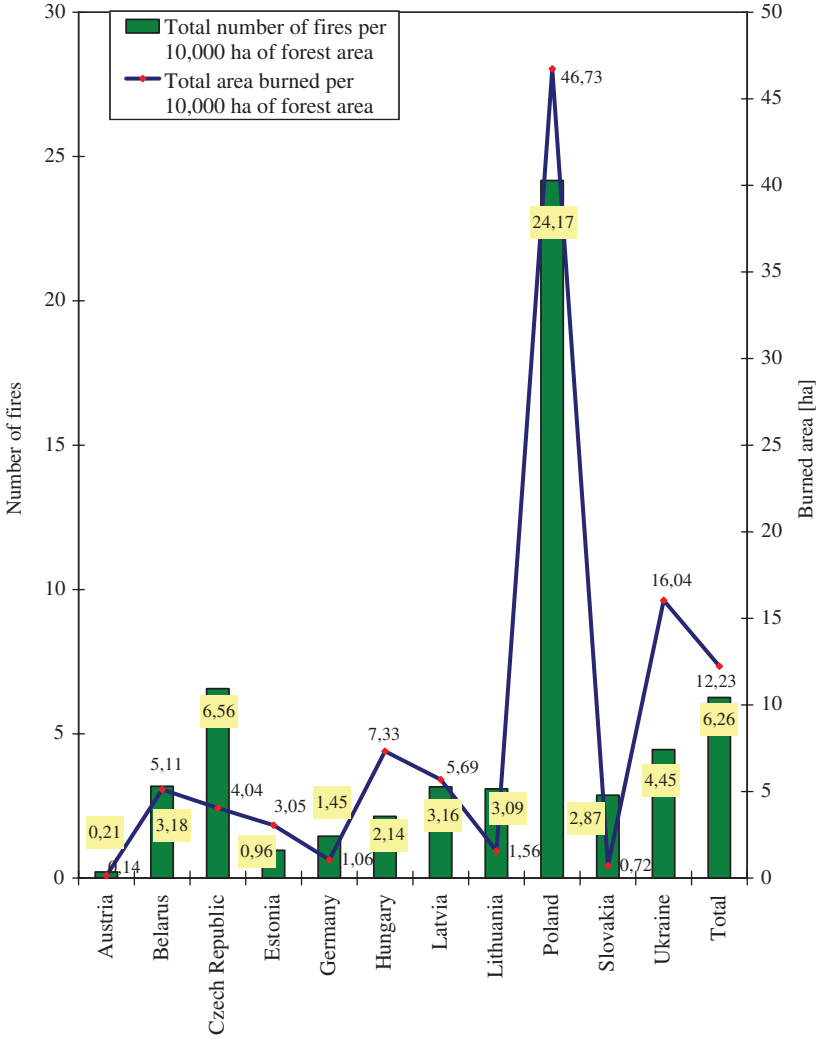


Figure 10.4. Mean annual number of fires and burned areas normalized by 10,000 ha of forest in CEE countries in 1991–2001.

radiation. During burning of vegetation, biomass carbon is released mainly as carbon dioxide (CO_2) and carbon oxide (CO), as these gases contribute to about 45% of the dry matter loss. When ground fires take place (and those are characterized by long-term processes of smoldering), methane (CH_4) as well as other hydrocarbons and organic acids are

released (Goldammer et al., 1997). Currently, an awareness that emissions from forest fires have a strong impact on global and regional air pollution, which has deleterious effects on ecosystems and people, has increased.

10.3. Methods of determining amounts of fire emissions

In order to determine the amounts of substances emitted during forest fires and fires on barren land, the data on fires from 1991 to 2001 were analyzed. Data concerning fires and burned area were obtained from the Food and Agriculture Organization of the United Nations (FAO) reports (FAO, 2001; UNEP/FAO, 2002), and for Poland these were additionally verified on the basis of updated statistical data (Forest fires in Europe, 2004, 2005, 2006; Forestry, 1991–2001; Perlińska, 2000, Reports on the state of forests in 2001; Statistical tables for rescue operations for 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001; Ubysz, 2003; Ubysz and Szczygieł, 2002, 2005; Ubysz et al., 2005) and corrected in terms of the type of fire and its percentage in the total number of fires. This permitted a more accurate calculation of gas emissions generated by fires, by assuming an amount of biomass burnt corresponding to the type of fire. For Poland complete data concerning barren land since 1994 were available. For the remaining countries, the most complete data were for the Ukraine and Lithuania, followed by Latvia, Estonia, and Belarus, while for Germany and Hungary data were not available. Five types of emissions were taken into account for calculations, including carbon dioxide, solid and liquid particles (smoke), hydrocarbons, and nitrogen oxides (NO_x). Magnitudes of emissions were determined on the basis of amount of green biomass per unit area that was burned in forests and in barren land. Type of fire was also considered (surface fire, crown fire, and for Poland, ground fire), as well as the amount of burned green biomass. For 10 countries (except Poland), fixed percentages of surface fires (85%) and crown fires (15%) were assumed. For Poland the real annual values were used (e.g., contribution of fires of soil cover in the analyzed period varied from 74% in 1999 to 88% in 2001). Amounts of green biomass for 10 countries (except Poland) were used according to the FAO data (Table 10.1) (UNEP/FAO, 2000). For Poland data for analysis were taken from research on evaluation of amount of biomass predestinated to burning in local conditions (Fraszewski, 1997). Hence, for forests a value of $82\,t\,ha^{-1}$ was used for surface fire and ground fire and $94\,t\,ha^{-1}$ for crown fire. These values correspond to 55-year-old pine stands located on forest sites with soil covered with litter. For barren land, $55\,t\,ha^{-1}$ was assumed as

the amount of biomass for all countries. Magnitudes of emissions released as a result of burning of 1 t of forest combustible materials (Fraszewski, 1997; Goldammer, 1993) were assumed as follows: carbon dioxide: 1375.0 kg; carbon oxide: 125.0 kg; solid and liquid particles: 50.0 kg; hydrocarbons: 12.5 kg; nitrogen oxides: 2.5 kg.

10.4. Emissions from forest fires

Amounts of emissions released as a result of fires of forests and barren land for CEE countries between 1991 and 2001 are presented in Table 10.4, and Table 10.5 presents these data separately for Poland. According to the calculations during this period in the analyzed region of Europe, the following amounts of emissions were released due to the forest and barren land fires

- 46,416,000 t of CO_2
- 4,403,000 t of CO
- 1,689,000 t of solid and liquid particles
- 425,000 t of hydrocarbons
- 87,000 t of NO_x.

The maximum emission level of combustion products was recorded in 1996; in total, it amounted to as much as 8,793,000 t (without Poland), representing 45% of the total gas emissions caused by forest fires from 1991 to 2001. The magnitude of this release in 1996 was affected by the size of the area burnt in Ukraine, which was as much as 127,061 ha. Similarly, in Poland, the maximum emission level was recorded in 1996 (5,635,000 t); in addition, a very similar emission level (5,539,000 t) was recorded in 1992. The lowest levels of combustion products from forest and wildland fires were released in 1991, both in Poland and the other CEE countries. The mean annual emission level for Poland was 3,068,000 t, and it was 1,753,000 t for other countries. The specific situation in Poland is a result of a large number of arson cases, varying in different years from 35% to 47%, of all the causes of forest and wildland fires. Compared with other countries, there is also much burning of plant remains in the fields and uncultivated farmland (which is illegal under the law). This is a very frequent cause of forest fires, representing as much as a dozen percent of all the causes. After Poland's accession to the European Union (EU), the fires breaking out as a result of this were substantially limited by the threat that assistance grants from the EU resources would be withdrawn in the event of burning out fields and meadows.

Table 10.4. Emissions released due to forest and wildland fires in 10 CEE countries (except Poland) in 1991–2001

Year	Forests					Wildland					Total—forests and wildland				
	Amounts of the released emissions (thousands of tons)														
	CO_2	CO	Solid and liquid aerosols (smoke)	Hydro-carbons	NO_x	CO_2	CO	Solid and liquid aerosols (smoke)	Hydro-carbons	NO_x	CO_2	CO	Solid and liquid aerosols (smoke)	Hydro-carbons	NO_x
1991	495	47	18	4	1	[a]	[a]	[a]	[a]	[a]	495	47	18	4	1
1992	2042	193	74	19	4	871	82	32	8	2	2913	275	106	27	6
1993	656	62	24	6	1	60	6	2	1		716	68	26	7	1
1994	950	90	35	9	2	20	2	1			970	92	36	9	2
1995	471	45	17	4	1	244	23	9	4		715	68	26	8	1
1996	7536	713	274	69	14	156	21	8	2		7692	734	282	71	14
1997	491	45	18	4	1	119	11	4	1		610	56	22	5	1
1998	498	47	18	5	1	28	3	1			526	50	19	5	1
1999	758	72	28	7	1	345	33	13	3	1	1103	105	41	10	2
2000	453	43	16	4	1	84	8	3	1		537	51	19	5	1
2001	587	55	21	5	1	7	1				594	56	21	5	1
Total	14,937	1412	543	136	28	1934	190	73	20	3	16,871	1602	616	156	31
Mean	1357.9	128.4	49.4	12.4	2.5	193.4	19.0	8.1	2.9	1.5	1533.7	145.6	56.0	14.2	3.8

[a]No data.

Table 10.5. Emissions released due to forest and wildland fires in Poland in 1991–2001

Year	Forests					Wildland					Total—forests and wildland				
	Amounts of the released emissions (thousands of tons)														
	CO_2	CO	Solid and liquid particles (smokes)	Hydro-carbons	NO_x	CO_2	CO	Solid and liquid particles (smokes)	Hydro-carbons	NO_x	CO_2	CO	Solid and liquid particles (smokes)	Hydro-carbons	NO_x
1991	284	27	10	3	1	[a]	[a]	[a]	[a]	[a]	284	27	10	3	1
1992	4849	461	176	44	9	[a]	[a]	[a]	[a]	[a]	4849	461	176	44	9
1993	919	87	33	8	2	[a]	[a]	[a]	[a]	[a]	919	87	33	8	2
1994	1016	97	37	9	2	1453	137	53	13	3	2469	234	90	22	5
1995	574	55	21	5	1	1009	95	37	9	2	1583	150	58	14	3
1996	1547	148	56	14	3	3387	320	123	31	6	4934	468	179	45	9
1997	724	69	26	7	1	3162	299	115	29	6	3886	368	141	36	7
1998	440	42	16	4	1	2008	190	73	18	4	2448	232	89	22	5
1999	939	90	34	9	2	2078	197	76	19	4	3017	287	110	28	6
2000	784	74	28	7	1	1834	173	67	17	3	2618	247	95	24	4
2001	383	36	14	3	1	2155	204	78	20	4	2538	240	92	23	5
Total	12,459	1186	451	113	24	17,086	1615	622	156	32	29,545	2801	1073	269	56
Mean	1133	107.8	41.0	10.3	2.2	2135.8	201.9	77.8	19.5	4	2685.9	254.6	97.5	24.5	5.1

[a]No data.

10.5. Conclusions

The emission level of combustion products caused by forest and wildland fires in the CEE countries from 1991 to 2001 amounted to 53,020,000 t. Almost 64% of the emissions came from Poland; this resulted from both the particular fire danger posed to its forests (because of the species composition of stands, poor sites, and young stands) as well as arson, which were the primary causes of fires. As a result of this, 60% of all the fires recorded in the period in question in the CEE countries broke out in Poland. The progressive climate warming causes an increase in fire danger and the number of forest fire outbreaks. Therefore, it should be expected that the air pollution caused by emissions due to forest fires will grow. This situation can be significantly improved through application of preventive measures and education efforts, which should contribute to the reduction of forest fires. In turn, improvement of the effectiveness of firefighting, through application of new technical solutions, provides an opportunity to limit burned area of forests and volume of fire emissions.

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