JOURNAL OF FOREST SCIENCE, *59*, 2013 (2): 41–53

Forest fires and their causes in the Czech Republic (1992–2004)

E. Kula, Z. Jankovská

Department of Forest Protection and Game Management, Faculty of Forestry and Wood Technology, Mendel University in Brno, Brno, Czech Republic

ABSTRACT: Forest fires under conditions of the Czech Republic are evaluated from the aspect of their frequency of occurrence in 1992–2004 at a level of particular years, seasons, days and daytime, and causes of their origin. They are confronted with a situation in the CR in 1974–1983. Effects of climatic conditions are a limiting factor not only for the frequency of their origin but also for the size of the burnt area. Spring (April) and summer (August) culminations were balanced. The burnt area of the best part of forest fires (88.9%) was < 1 ha. The increased frequency of forest fires was noted in afternoon hours and during weekends. Areas threatened by fires are characterized by the increased visit number. In the spectrum of causes, a dominant position is taken up by fire raising, smoking and management in the forest. Railway operation and lightning represent minority causes of the origin of forest fires. In the course of the year, the structure of forest fire origin changes depending on activities in the forest and visit number.

Keywords: fire risk; preventive measures; occurrence; burnt area; season; frequency

Forest fires depending on site conditions and their extent can disturb the stability of forest ecosystems. Affected areas show changes in their water regime, in the content and composition of nutrients and their cycling, physical and chemical properties of soil (Boerner 1982; Kubíček, Šomšák 1982; Certini 2005; Šomšák et al. 2009). Extensive forest fires affect the air quality even to a long distance (Li et al. 2010). Trees and sites affected by forest fires create conditions for the development of some saproxylic species, e.g. *Melanophila acuminata* (DeGeer) (Evans 2010; Boulanger et al. 2010). In Europe, Mediterranean regions unambiguously differ from regions of central and northern Europe (Anonymous 2005) in the frequency and extent of burnt areas.

Measures proposed in the area of the prevention of origin and elimination of forest fires can also be based on the evaluation of forest fires in relation to climatic factors, season, daytime, and causes of their origin. With the development of society, characteristics of forest fires also partly change, particularly the proportion of causes of their origin. In addition to ordinarily occurring types of forest fires (ground, surface, crown) the fire of a gale-disaster area (Chromek 2006) was newly attached to the types mentioned above due to the specific properties of the fire spreading. In relation to papers of Nechleba (1927), Pfeffer (1938, 1961), Felix (1948), Hodr (1963) and Kunt (1967), forest fires in the CR were described by Kula (1980, 1981a–c, 1985a,b). Forest fires in the CR are caused nearly exclusively by an anthropogenic factor, because the proportion of fires initiated by lightning does not exceed 2% (Kula 1985b). The aim of the paper is to characterize forest fires in 1992–2004 and changes in comparison with the period of 1974–1983 from the aspect of their occurrence and causes of origin.

METHODS

The database of 15,985 forest fires (1992–2004) results from the manually verified central records

Supported by the Ministry of Education, Youth and Sports of the Czech Republic, Project No. MSM 6215648902, Netex Ltd., Constellium Decin Extrusions Ltd., District authorities in Decin, Nadace CEZ Co. Prague, Lafarge Cement Co. in Cizkovice, Severoceske doly Co. Chomutov, Dieter Bussmann Ltd.

of fires of the General Directorate of Fire Rescue Service of the Czech Republic (GR HZS CR) to exclude non-forest fires such as fires of woody ornamentals in parks, grass fires in fields and meadows etc. as well as data on forest fires from the period of 1974–1983 (Kula 1985a,b). Climatic characteristics (mean temperatures and regional precipitation for the CR in 1992–2004) were provided by the Czech Hydrometeorological Institute (CHMU) in Prague.

To process data, forest fires were categorized by their size (< 100 m^2, 100–1,000 m^2, 0.1–1 ha, 1–5 ha, 5–30 ha, 30–50 ha, 50–80 ha, ≥ 80 ha) as well as by the time of their outbreak (0–9, 9–11, 11–13, 13–15, 15–17, 17–19 and 19–20 h). With respect to the change in the procedure of fire records after 1990, comparable categories (0–10/0–128; 11–20/129–256; 21–30/257–384; 31–40/385–512; 41–50/513–640; 50+/641+) were created for the purpose of comparing the periods of 1974–1983 and 1992–2004. Causes of forest fires were united and at the establishment of fires in nature and at landings, a separate category management in the forest was detached in the period 1992–2004.

Climatic conditions

The second half of the monitored period (1992–2004) was characterized by marked deviations in total precipitation on the area of the CR. The year 2003 was dry (507 mm) as against the 1961–1990 normal (672 mm), the years 1992 (April–May and August–September) and 1999 (May, August) were subnormal in precipitation. The years 2001 (March–April and July–September), 2002 (August–November) and 1995 (March–June and August–September) were classified as very rich in precipitation. Other years (in spite of partial monthly extremes) oscillate at a level of the long-term normal (Fig. 1). Mean temperatures ranged above the long-term normal of 7.5°C (1961–1990) throughout the monitored period (with the exception of 1996). The months of January–March and August were affected by a marked decrease of temperatures in 1996 (Fig. 1).

RESULTS

Forest fire occurrence

In the monitored period (1992–2004), some 15,985 forest fires with the total burnt area of 7,825 ha were registered. The frequency of occurrence and the size of the affected area were influenced particularly by climatic conditions. Forest ecosystems were threatened most by fires in 1992 (13.9% fires, 14.6% burnt area, mean 0.52 ha·fire^{-1}) and further in 1998 (10.7%), 1994 (10.5%) and 2003 (10.2%) (Table 1). The year 1996 was characterized by the largest total burnt area (21.9%), on average 1.74 ha·fire^{-1} (Table 1).

The highest number of forest fires broke out in August (19.3%) and April (18.8%) when the most extensive area was burnt, namely 44.8% (1.16 ha·fire^{-1}) (Fig. 2). In spring months, the frequency of fires up to an area of 0.01 ha decreased, on the other hand, the frequency of fires of an area of 0.1–1 ha and 1–5 ha increased. Fires of an area of 0.01–0.1 ha occurred all the year round, particularly in the growing season (Fig. 3). Forest fires most often (51.3%) started in the afternoon (13–18 h), particularly between 14 and 16 h (23.2%) (Fig. 4). The burnt area of the best part of forest fires (88.9%) was < 1 ha (long-term average 0.49 ha·fire^{-1}). Large fires (≥ 5 ha) were recorded sporadically (1.5%) but with the dominant propor-

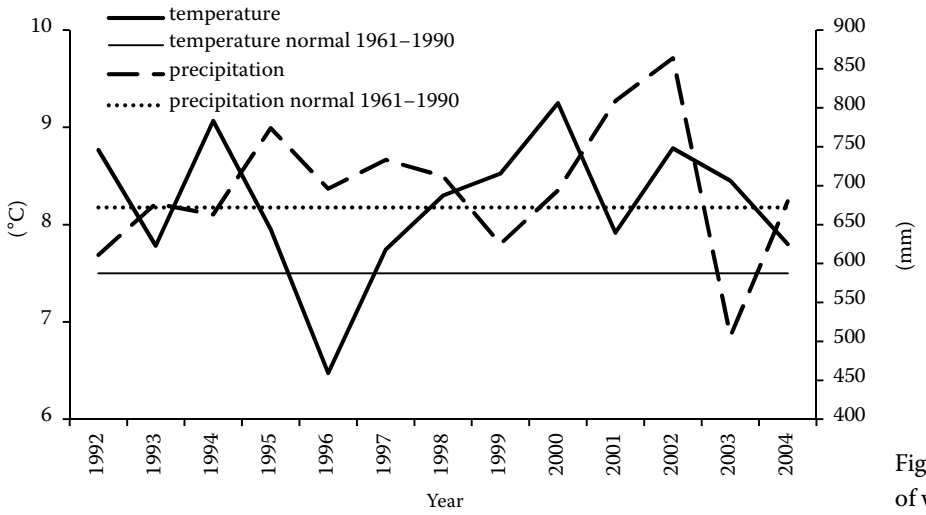


Fig. 1. Characteristics of the course of weather in the CR (1992–2004)

Table 1. The frequency of forest fires and the extent of burnt area in the CR (1992–2004)

		1992	1993	1994	1995	1996	1997	1998
Forest fires	*n*	2,220	1,595	1,674	1,061	984	970	1,710
	(%)	13.9	10	10.5	6.6	6.2	6.1	10.7
Burnt area	(ha)	1,144	1,041	667	363	1,714	260	786
	(%)	14.6	13.3	8.5	4.6	21.9	3.3	10.1
Mean	(ha·fire^{-1})	0.52	0.65	0.4	0.34	1.74	0.27	0.46
		1999	2000	2001	2002	2003	2004	Total
Forest fires	*n*	1,183	1,320	421	402	1,632	813	15,985
	(%)	7.4	8.3	2.6	2.5	10.2	5.1	100
Burnt area	(ha)	276	352	71	127	731	294	7,825
	(%)	3.5	4.5	0.9	1.6	9.3	3.8	100
Mean	(ha·fire^{-1})	0.23	0.27	0.17	0.32	0.45	0.36	0.49

tion in the total burnt area (47.6%). More extensive areas affected by forest fires originated during weekends (Fig. 5). Most fires were reported in the North-Bohemian (18.7%) and Central-Bohemian Regions (17.8%) and the maximum total burnt area in the South-Moravian (20.8%) and West-Bohemian Regions (18.3%) (Fig. 6). The most risky area in the monitored period (1992–2004) was the area of the Česká Lípa district and the area of the Krušné hory Mountains (Děčín, Ústí nad Labem, Teplice, Most and Chomutov districts) and the Bohemian-Moravian Uplands (Figs. 7 and 8).

Causes of forest fires

In the spectrum of forest fire causes (1992–2004), fire raising (22.6%) with the proportion of total burnt area 22.1% showed a dominant position followed by smoking (22.4/17.3%), management in the forest (10.1/11.7%) (originally included in the category of fire raising), children under 15 years (4.6/3.1%). Unexplained fires accounted for a high percentage (29.9/33.3%). Fires caused by the railway operation (1.88 ha·fire^{-1}) and as a result of technical defects (1.20 ha·fire^{-1}) were not numerous, however, their

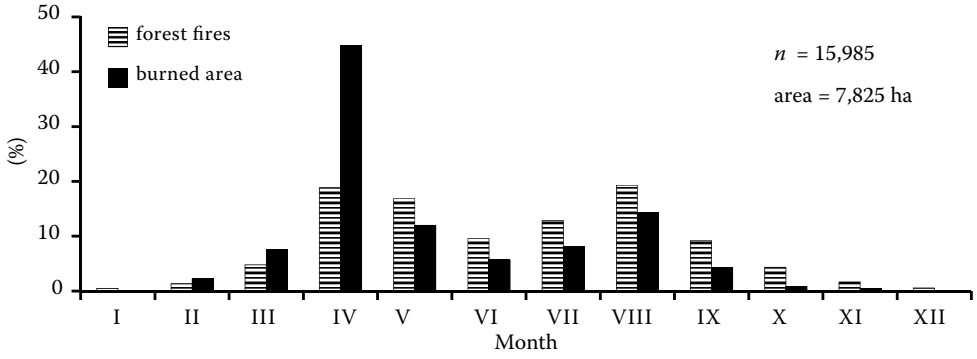


Fig. 2. Frequency and extent of forest fires during the year (1992–2004)

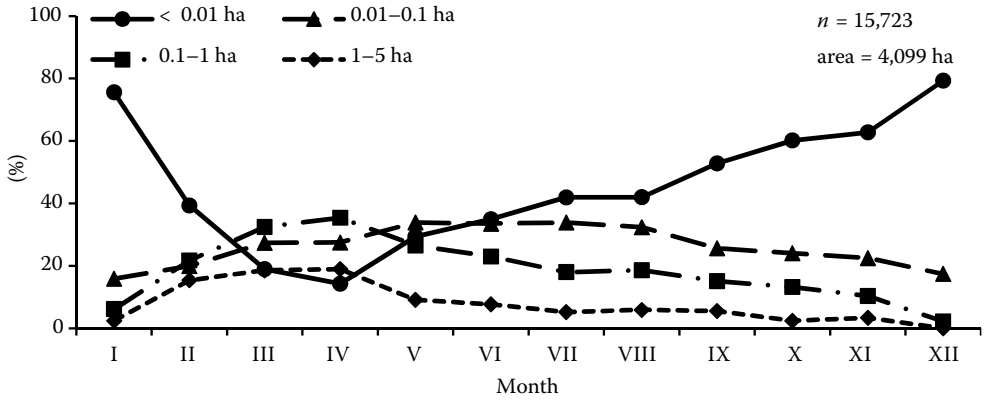


Fig. 3. Seasonal dynamics of forest fires depending on the extent of burnt area (1992–2004)

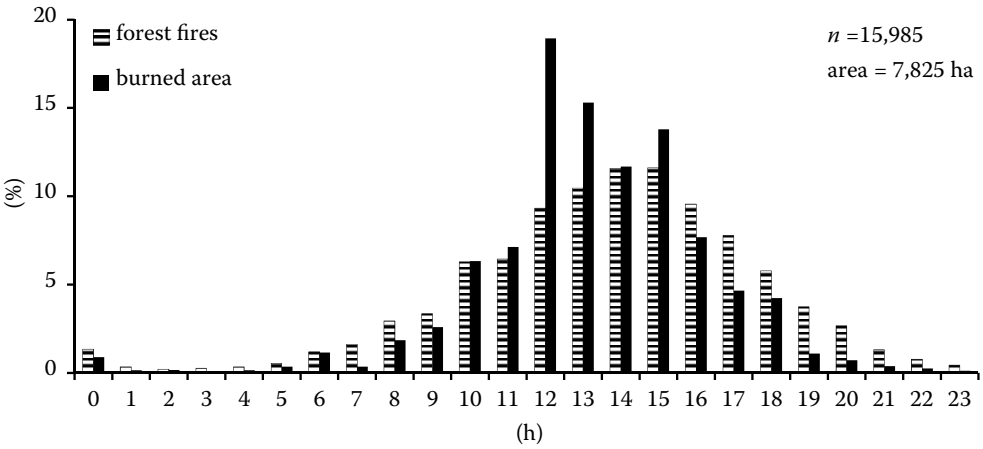


Fig. 4. Dynamics of the occurrence of forest fires in the CR during the day (1992–2004)

area was large. Under Central-European conditions, the significance of lightning is low (Table 2).

The setting of fires in the forest became evident by the increased frequency in 1992–1994 (10.3 to 14.4%) and, generally, this cause was related to the spring season – April (21.2%; burnt area 46.4%, 1.05 ha·fire^{-1}) and March (1.02 ha·fire^{-1}) (Fig. 9) and weekends (34.2%). This reason was profiled more markedly in the southern part of the Central-Bohemian Region and in the South-Bohemian Region, particularly on the border with Austria, in the Bohemia-Moravian Uplands and Northern

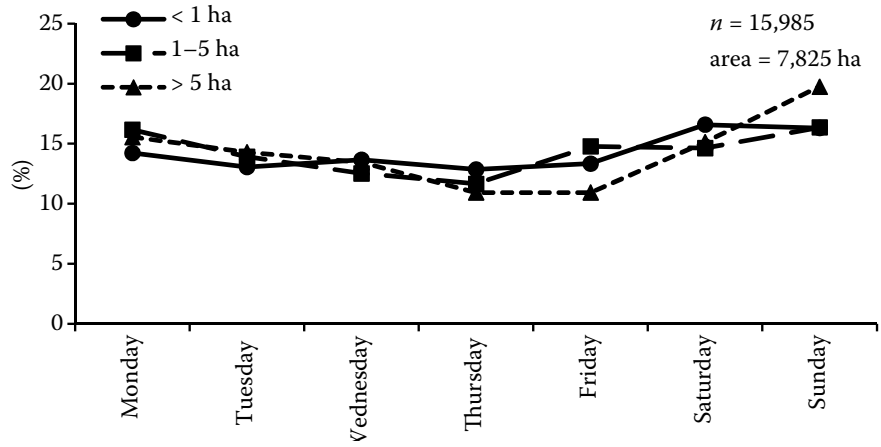
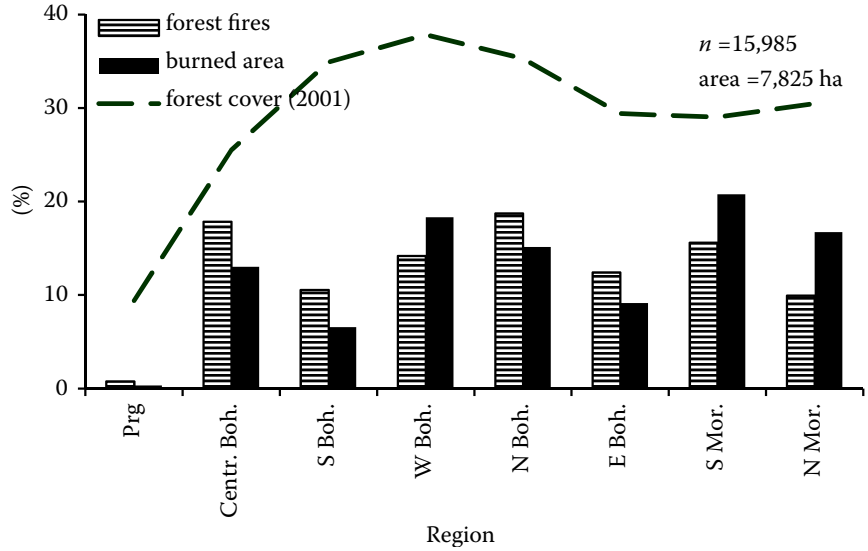


Fig. 5. Distribution of the total burnt forest area in the CR during the week (1992–2004)



Prg – Prague, Centr. Boh. – Central Bohemia Region, S Boh. – South Bohemia Region, W Boh. – West Bohemia Region, N Boh. – North Bohemia Region, E Boh. – East Bohemia Region, S Mor. – South Moravia Region, N Mor. – North Moravia Region

Fig. 6. The proportion of forest fires and burnt area according to regions of the CR and forest cover percentage (1992–2004)

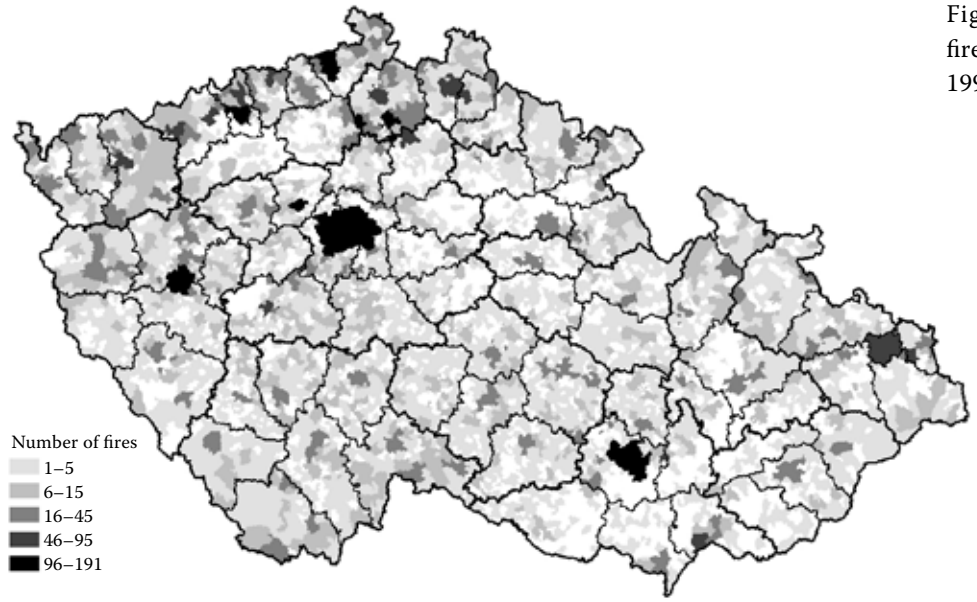


Fig. 7. Number of forest fires in municipalities (CR, 1992–2004)

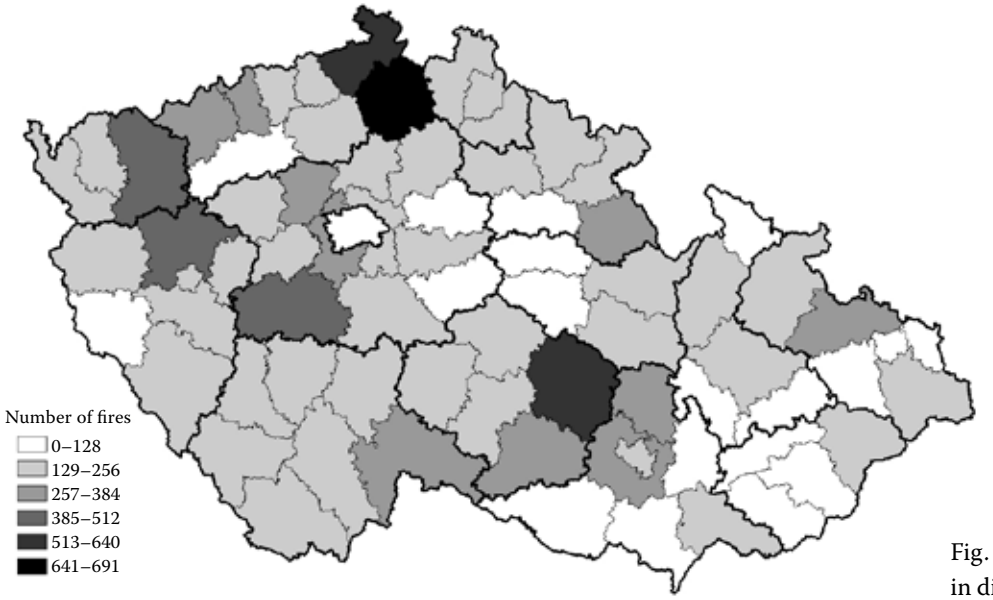


Fig. 8. Number of forest fires in districts (CR, 1992–2004)

Bohemia (Česká Lípa, Děčín districts and Liberec) (Fig. 10).

The category of management in the forest includes forest fires that most often broke out during the burning of logging slash or due to negligence of forest workers (smokers, insufficiently extinguished fire) (Table 2). An increased percentage of fires of this category is reported in April (43.5%) and in May (13.2%), August culmination is missing. The time of fire outbreak is most often at 11–14 h (32.7% fires, 44.3% burnt area).

Areas with the increased occurrence of fires of this category were in the South-Bohemian and Central-Bohemian Regions (Jindřichův Hradec, Tábor, Pelhřimov, Benešov, České Budějovice and Písek districts), 275 fires (17.4%) with the burnt area of 116.6 ha (0.42 ha·fire^{-1}) and in the East-Bohemian and South-Moravian Regions (Žďár nad Sázavou, Blansko, Brno venkov, Svitavy, Ústí nad Orlicí, Rychnov nad Kněžnou districts) with 406 fires (25.7%) with 211.8 ha of burnt area (0.52 ha·fire^{-1}) (Fig. 11).

Smoking caused 22.4% fires (1350 ha, 0.38 ha·fire^{-1}). July–August (41.5%) or May (16.4%) are risky months; as for the size of burnt area, it is April (49.2%) (Fig. 12). Slightly increased occurrence is characteristic of weekends (33%) an surprisingly Monday (39%). Fires caused by smoking occurred most frequently at afternoon hours (13–17 h; 41.8%). Dečínsko, Českolipsko, Krušnohoří and Podkrkonoší and the surroundings of Prague (particularly the south) were mostly threatened by smokers.

Children under 15 years caused relatively few forest fires (731; 4.6%) of an area of 241 ha (3.1%) and

Table 2. Causes of forest fires and the extent of burnt area in the CR (1992–2004)

Causes	Forest fires		Burnt area		Mean (ha·fire^{-1})
	n	(%)	(ha)	(%)	
Unexplained	4,778	29.89	2,603.71	33.28	0.54
Heating devices and flue ways	9	0.06	0.60	0.01	0.07
Operation-technical defects	133	0.83	159.99	2.04	1.20
Combustible and explosive materials	2	0.01	0.31	0	0.15
Extraordinary events	230	1.44	113.50	1.45	0.49
Intention, incendiarism (arson)	550	3.44	165.22	2.11	0.30
Children up to the age of 15 years	731	4.57	240.67	3.08	0.33
Smoking	3,585	22.43	1,350.44	17.26	0.38
Fire raising	3,611	22.59	1,731.99	22.13	0.48
Management in forests	1,615	10.10	917.69	11.73	0.57
Negligence of adults	288	1.80	151.84	1.94	0.53
Railway operation	166	1.04	311.94	3.99	1.88
Blasts and self-ignition	65	0.41	42.52	0.54	0.65
Lightning	222	1.39	34.40	0.44	0.15
Total	15,985	100	7,824.79	100	0.49

size 0.33 ha·fire^{-1}. It concerned most often playing with matches and children's smoking (hiding in the forest), starting a camp-fire in the forest or in its vicinity or games with consumer pyrotechnics.

Spring months (April–May; 45.6%) and holidays (July–August; 25.4%) were a critical period (Fig. 13). The occurrence of fires was slightly increased at the end of the week (Friday–Sunday; 46.2%). During the day, fires occurred particularly between 13 and 19 h (73.6%). The North-Bohemian Region (29.1%) and the surroundings of larger cities (Prague, Brno, Kladno) and Ústí nad Labem, Most, Teplice and Chomutov districts were threatened to the greatest extent (Fig. 14).

Intentionally started fires in the forests (550, 3.4%) with the burnt area of 165.2 ha (2.1%) happened particularly in the dry year 2003 (12.7%). Arsonists set on fire piles of logging slash, grass or feed racks. An increased occurrence was in May (20.2%) and in the period of July–September (45.6%) (Fig. 15) with the culminating burnt area in April–May (51.1%). During a week, these fires started uniformly with a marked shift towards afternoon and night hours (41.5%) after 16 h. Risky areas were in the vicinity of Kladno (64 cases), Meziboří Most district (25), Litvínov (16) and Děčín (12).

The railway operation is not important any longer as a factor of the forest fire outbreak. The occurrence decreased down to 0.01% (2004), but generally, the large average burnt area (1.88 ha·fire^{-1}) is characteristic of this cause, particularly at August and April fires (> 2.5 ha). Fires started within a

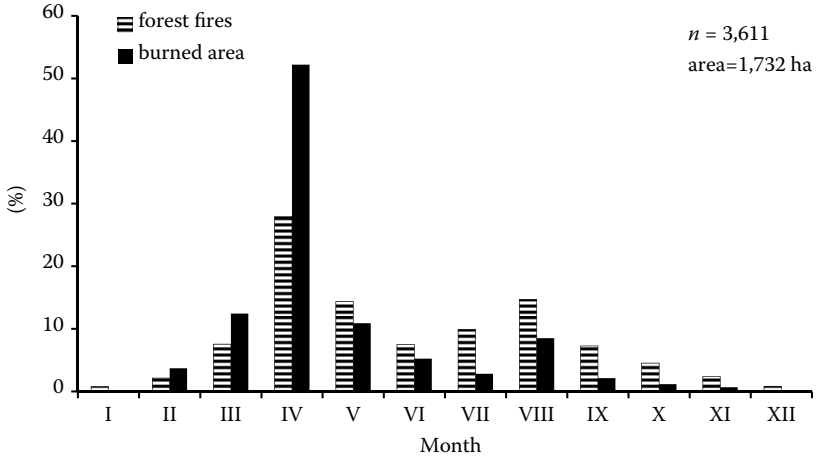


Fig. 9. The frequency and the extent of forest fires during the year in the CR (cause: fire raising; 1992–2004)

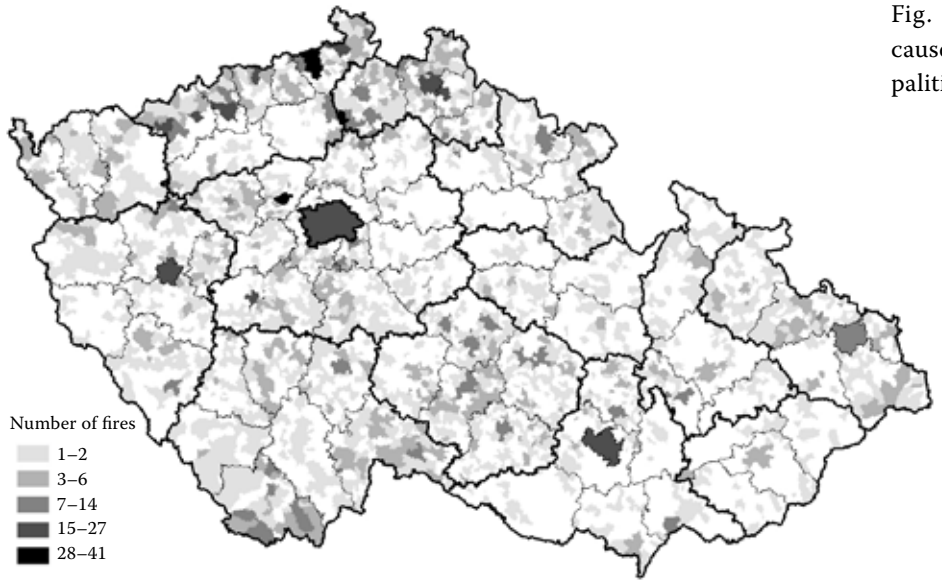


Fig. 10. Number of forest fires caused by fire raising, in municipalities (CR, 1992–2004)

Fig. 11. Number of forest fires caused by management in forests, in municipalities (CR, 1992–2004)

broad time span of 9–19 hours unlike other causes. Track 080 Bakov nad Jizerou-Doksy is of interest, because 14 fires broke out there in the area of Bělá pod Bezdězem in the monitored period.

Lightning as an abiotic factor was the cause of a negligible number of fires (1.4%) and burnt area (0.5%). The fires generally happened in the growing season (Fig. 16). A higher percentage of light-

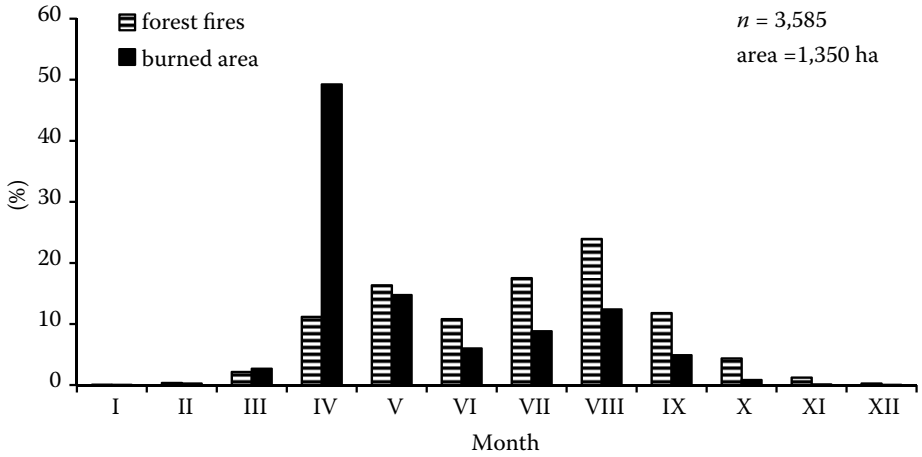


Fig. 12. The frequency and the extent of forest fires during the year in the CR (cause: smoking; 1992–2004)

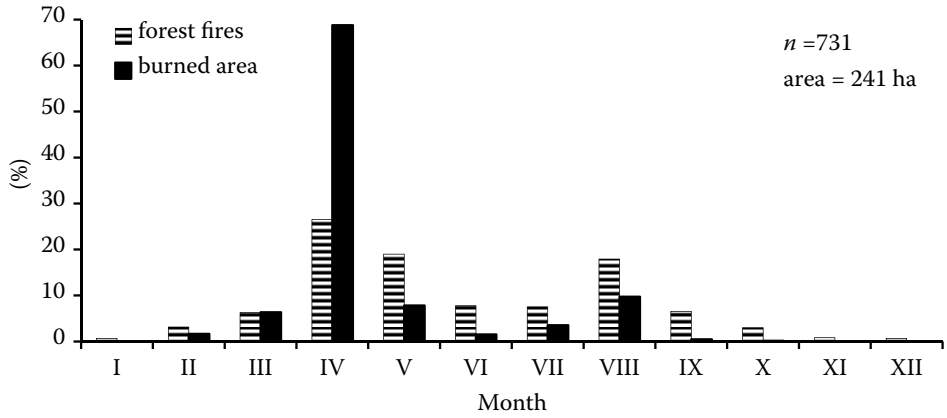


Fig. 13. The frequency and the extent of forest fires during the year in the CR (cause: children; 1992–2004)

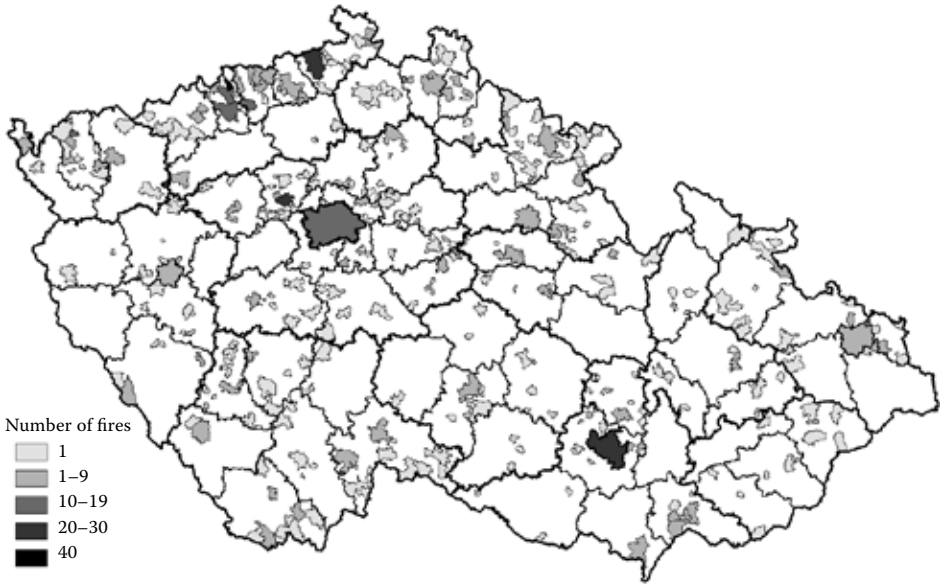


Fig. 14. The frequency and the extent of forest fires during the year in the CR (cause: arsonists; 1992–2004)

ning fires occurred in Jindřichův Hradec (8.2%) and Třebíč (7.7%) districts. The southern part of the CR was exposed to higher lightning frequency.

DISCUSSION

Distribution of forest fires

In the growing season, the frequency and extent of forest fires in the CR were unambiguously affected by climatic conditions, which follows from the situation of dry years (1992 and 2003) and years with above-average precipitation (2001 and 2002) (Fig. 17). Kula (1981) found that the precipitation-poor years 1974 and 1976 accounted for 73.7% of fires in 1974–1978 and in 1983, the number of fires (587) reached nearly a double of the 10-year average (311) (Kula 1985).

The average annual number of registered forest fires decreased from 341 (1974–1978) to 282 (1979–1983) and culminated with 1,230 fires·year^{-1} (1992–2004), the average area of fire diminish-

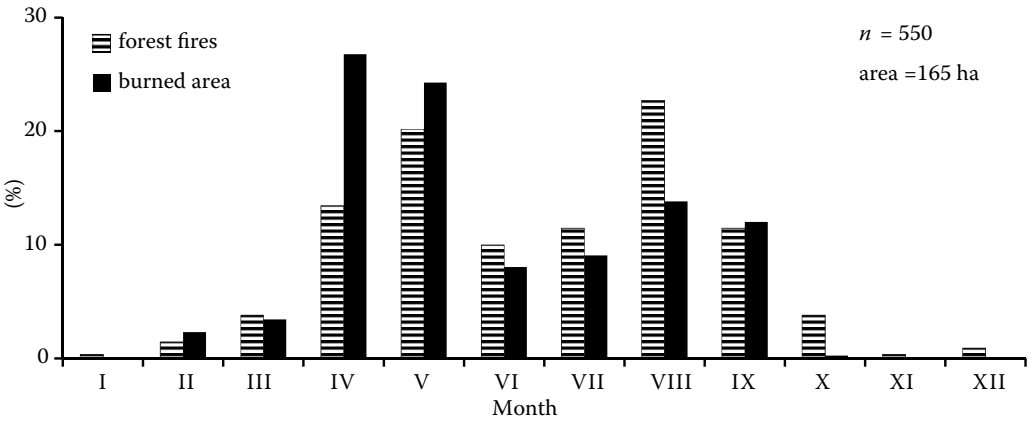


Fig. 15. Number of forest fires caused by children up to the age of 15 years, in municipalities (CR, 1992–2004)

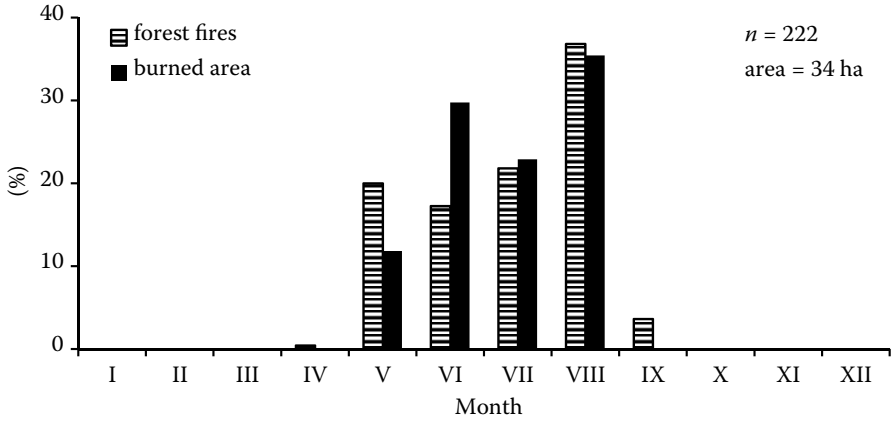


Fig. 16. The frequency and the extent of forest fires during the year in the CR (cause: lightning; 1992–2004)

ing from 2.35 ha·fire^{-1} to 1.58 (1979–1983) and 0.49 ha·fire^{-1} (1992–2004).

This development was caused by a change in the methodology of forest fire registration: since 1983, even so called seasoning has been reported as a fire. In the Mediterranean region, on average 49,357 fires per year broke out in 1980–2004, annual burnt area being 492,000 ha, average area of a fire 10 ha (Anonymous 2005). The month of April with its burnt area 44.8% is generally most dangerous (1992–2004) as demonstrated by long-term experience from 1974 to 1978 (40.3%) (Kula 1981) and 1979–1983 (34.8%) (Kula 1985). Particularly drought in spring months profiled with its annual proportion of fires in 1974 (April 44.7%; March 50.9%), 1976 (April 41.2%; May 35.6%) (Kula 1981) and 1979 (38.7%) and 1981 (61.4%) (Kula 1985). In general, two periods (March–April and July–August) are supposed to be the most critical time for forest fire outbreak.

The year 1996 is considered to be unusual as for the number of forest fires (6.6%) although it was a year with the precipitation normal and average. Nevertheless, in April, forest fires broke out in their extreme extent in relation to Central-European conditions with the proportion of annual burnt area 93.2% (2.3 ha·fire^{-1}). A half (50.1%) of the burnt area was caused by fires > 30 ha whereas April accounted for 32.5% throughout 1992–2004. An increase was noted particularly in the category ≥ 80 ha (36.3%) while April in 1992–2004 only 19.4%.

Since 1974, the distribution of forest fires has changed in the course of the year. A rise was proved in summer months (July–August) from 9.8% (1974–1978) (Kula 1981) to 24.4% (1979–1983) (Kula 1985) up to 32.2% (1992–2004) and a decline in spring months (March–May) from 80.5% (Kula 1981) to 55.4% (Kula 1985) to a balanced level in March–May (40.5%) and June–August (41.8%) (1992–2004) (Fig. 18).

In Poland, a seasonal maximum (60%) occurs in spring months (April–May) (Anonymous 2005). Annual maxima mentioned above (1992–2004) are profiled by causes of the forest fire origin, which reflect changing anthropogenic activities in forest ecosystems and areas related to them. The cause of management in the forest markedly decreased from 22.9% (April) to 2.3% (August) and smoking increased from 13.3% (April) to 27.8% (August) and the proportion of lightning from 1 (April) to 82 cases (August). The category of setting forest fires remains balanced 25.6% (April), 22.3% (August), children under 15 years 6.4% (April), 4.3% (August) (Fig. 19).

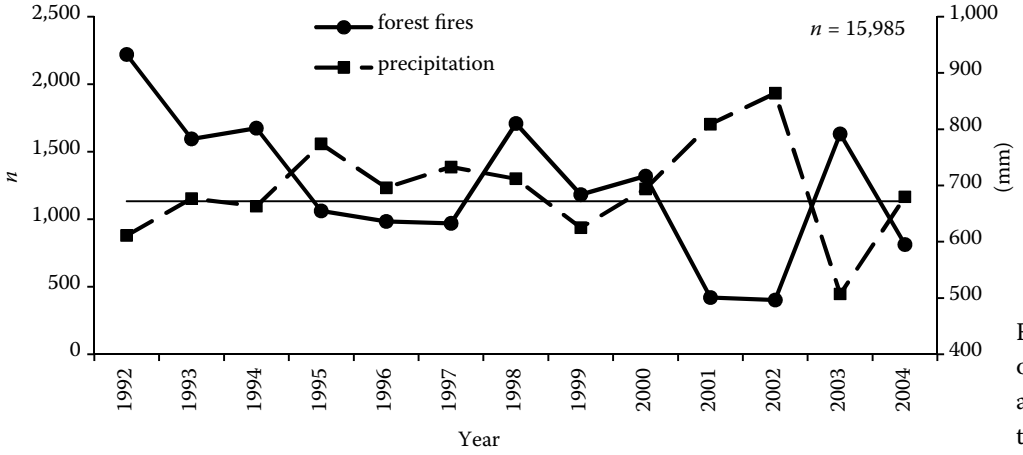


Fig. 17. The frequency of forest fires in the CR and average precipitation (1992–2004)

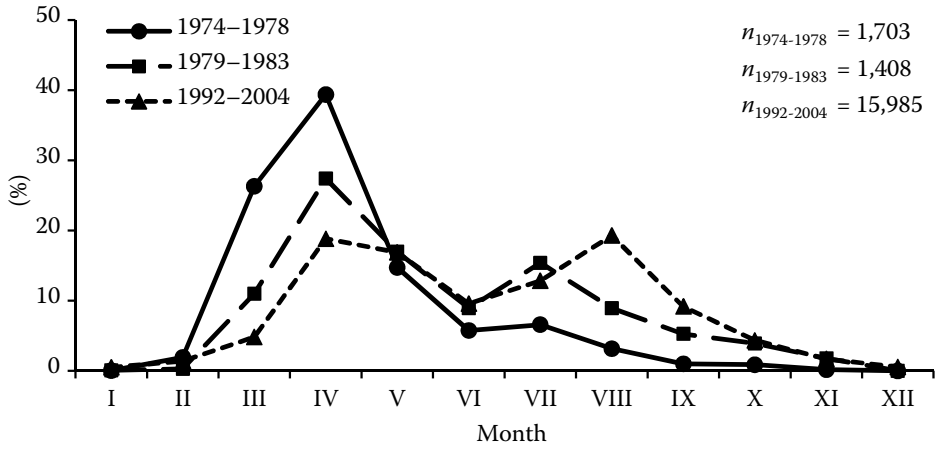


Fig. 18. The seasonal occurrence of forest fires in the CR (1974–2004

A partial increase in the occurrence of forest fires occurs during weekends (1992–2004) according to conclusions of Kula (1985). In the course of a working week, the proportion of forest fires was balanced whereas Kula (1985) showed a difference between Monday (17%) and Friday (10.7%).

The higher frequency of forest fires in the afternoon (12–14 h) was caused by more favourable climatic conditions – lower relative air humidity, higher temperature and solar radiation intensity, increased movement and activities of people in the forest. The high proportion of fires (> 50%) during management in the forest after 13 h was caused particularly due to negligence at the burning of logging slash (Fig. 20).

Increased storm activities and fires caused by lightning occurred in the afternoon and evening hours and at night (15–23 h). Children up to 15 years participated in the origin of fires between 13 and 17 h (30.4%) and adults between 15 and 23 h (56.0%). The distribution of forest fires during the day according to the fire size was different. Fires in the category < 1 ha occurred all day long, large fires ≥ 5 ha rather in the afternoon (13–17 h) (Fig. 21). The daily culmination of the occurrence of forest fires shifted from 11–15 h (62%) (Kula 1981) to 13–17 h (43.2%) (1992–2004) (Fig. 22).

Causes of forest fires

Causes of forest fires and their extent in the course of the year were dependent particularly on predominating activities of man in the forest or in its neighbourhood.

The main cause of the increased frequency of forest fires of an area of 1–5 ha in the spring season

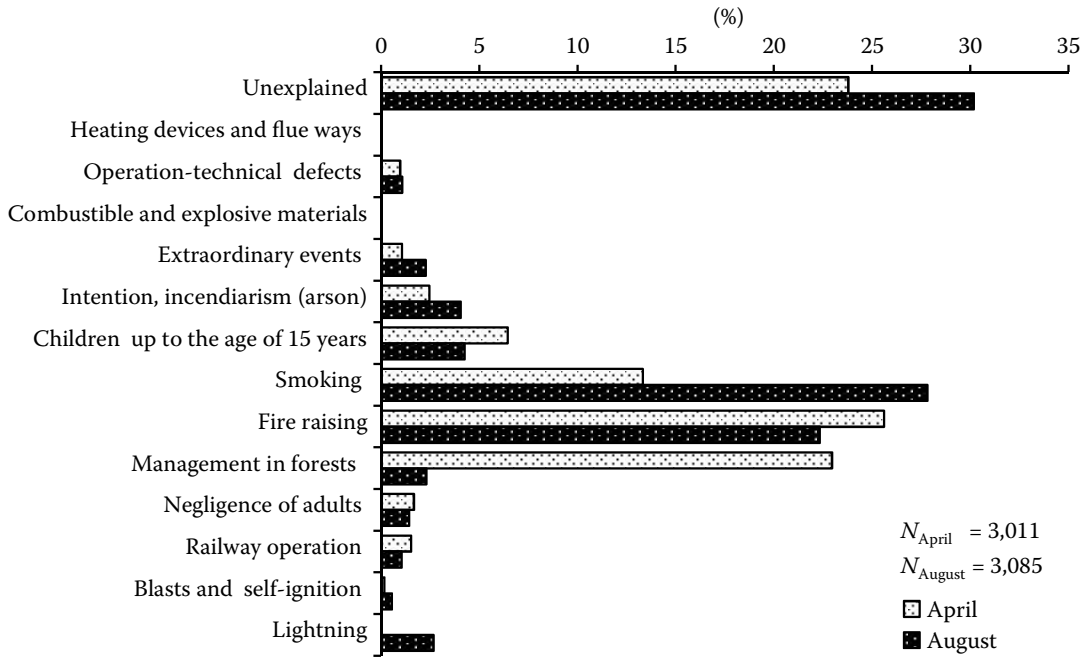


Fig. 19. Causes of the forest fire origin in the year culmination season (April, August 1992–2004)

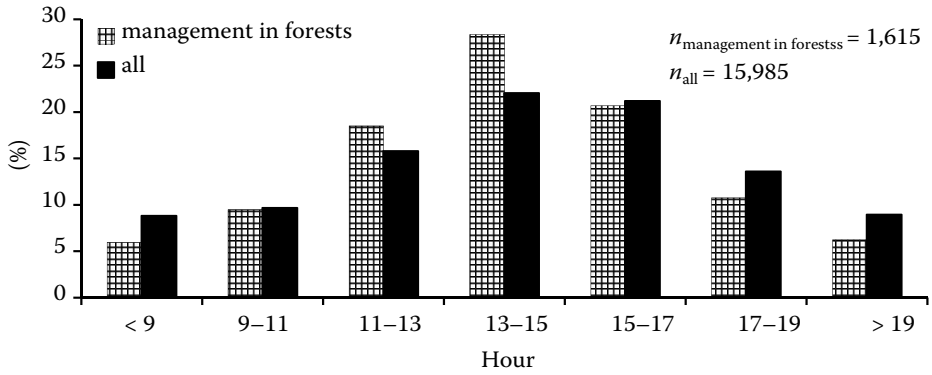


Fig. 20. The proportion of the forest management cause in forest fires in the CR during the day (1992–2004)

(February–April) was management in the forest (28.2%) and starting the fires (27.7%). Sparks from a steam engine (railway), which were the most important cause of forest fires in the first half of the 20th century (Pfeffer 1961), decreased to 5% and later down to 1% in the 70s and 80s of the last century (Kula 1985) (1992–2004) (Fig. 23).

In 1974–1979, sparks from the steam engine exhausts were one of the main causes (19.6%) of forest fires in the CR (Kula 1981). Effects of the railway modernization at the end of the 70s and the total removal of steam traction in 1980 resulted in the fall of the fires from 19% (1974) to 10.5% (1977) and 7.5% (1978) (Kula 1981).

According to Kula (1985), smokers travelling by train and carbon flying from exhausts of Diesel engines as well as hot cinders from braking blocks participate in the risk of the fire origin along railway. These facts were confirmed by the analysis of data from 1992 to 2004, the proportion of smokers being decreased.

Fires originating in forest management happened rather evenly early in spring and in autumn. This occurrence corresponded to activities in forest management: spring preparation for forest regeneration, logging operations, autumn reforestation. A reason for the origin of these fires consisted in negligence of forest workers and in the inobservance of principles for the burning of logging slash (burning under unsuitable climatic conditions in the period of dry or windy weather, insufficient localization and leaving places of burning beyond control) (Fig. 24).

Management in the forest as a cause of forest fires is a problem occurring particularly at private forest owners who burn logging slash not taking into account recommended safety measures. In Poland, up to 40% forest fires break out due to negligence and the high proportion of fire raising. The number of fires spreading into the forest from non-forest land increases (burning herbage and agricultural land) (Anonymous 2005).

Management in the forest as a cause of fires was included in the category of fire raising in nature in 1974–1983. Forest management workers participated there by 50% at logging slash burning (Kula 2006, oral communication), heating meals and pre-

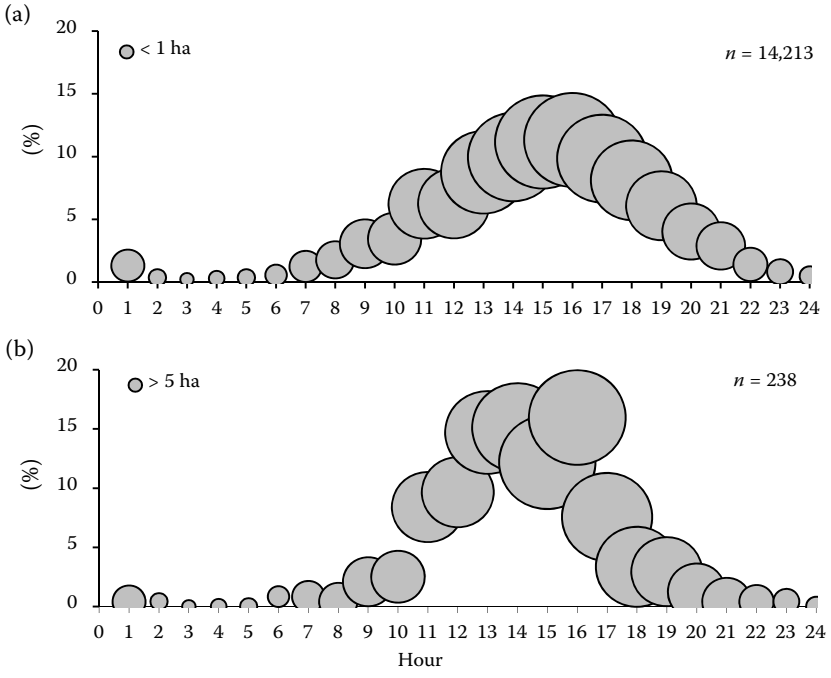


Fig. 21. The occurrence of forest fires of an area of < 1 ha and > 5 ha in the CR during the day (1992–2004)

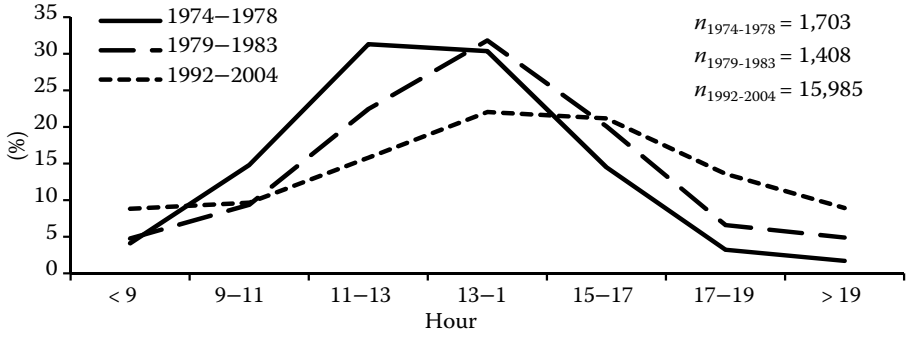


Fig. 22. The frequency of forest fires in the CR during the day (1974–2004)

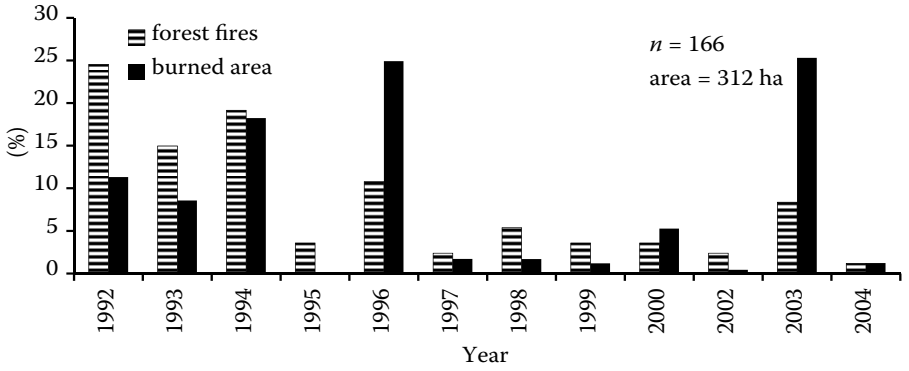


Fig. 23. The frequency of forest fires in the CR (cause: railway operation; 1992 to 2004)

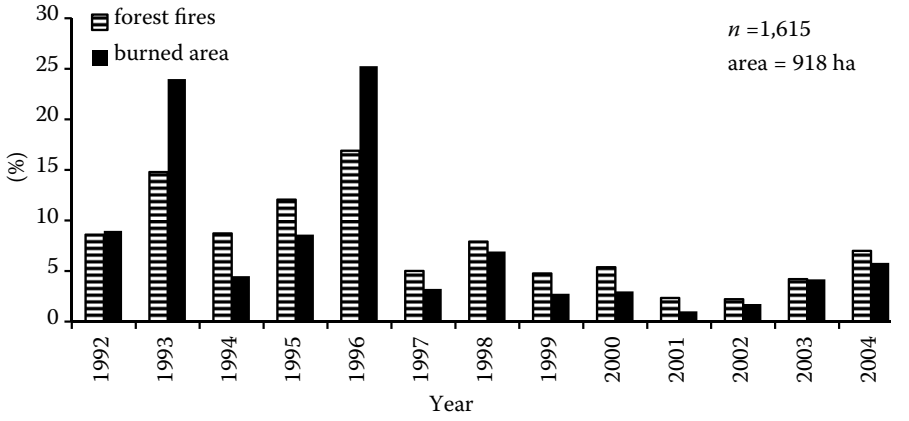


Fig. 24. The frequency and the extent of forest fires during the year in the CR (cause: management in forests; 1992–2004)

cociously leaving their workplace (Kula 1985). It is also related to the frequency of fires in the course of the day (11–13 h) (Kula 1985).

Lightning is an interesting cause of the origin of forest fires. Impacts of lightning in connection with forest fires are negligible. However, lightning causes physiological disorders and kills the affected as well as neighbouring trees to various extents, which creates an available area for the development of cambioxylophagous insects and the occurrence of bark beetle foci (Kula, Zábecki 1997a,b).

CONCLUSION

Under conditions of the Czech Republic, forest fires (15,985) correspond by their frequency and area (7,825 ha) to Central-European climatic conditions being the response of the forest cover percentage, visit number and the extent of measures aimed at the mitigation of the origin and effectiveness of forest fire elimination. Characteristics of fires that broke out in forest stands in the CR in 1992–2004 show that effects of climatic conditions are limiting not only for the frequency of fire origin but also for the size of a burnt area. Spring and summer culminations were balanced while in 1974–1983 spring culminations were dominant. The burnt area of the best part of forest fires (88.9%) was < 1 ha. Increased frequency of fires occurs in the afternoon, during the weekend. Endangered areas are characterized by the increased visit number. In the spectrum of causes, fire raising, smoking and management in the forest take up a dominant position. Railway operation and lightning represent minority causes of forest fires. In the course of the year, the structure of the forest fire ori-

gin changes depending on activities in the forest and visit number. Prevention realized by large forest owners reduces positively the risk of forest fires in forests.

References

Anonymous (2005): Forest fires in Europe 2004. Available at http://www.fire.uni-freiburg.de/programmes/eu-comission/EU-Forest-Fires-in-Europe-2004.pdf

Boerner R.E.J. (1982): Fire and nutrient cycling in temperate ecosystems. Bioscience, ***32***: 187–192.

Boulanger Y., Sirois L., Hebert C. (2010): Distribution of saproxylic beetles in a recently burnt landscape of the northern boreal forest of Québec. Forest Ecology and Management**,** ***260***: 1114–1123.

Certini G. (2005): Effects of fire on properties of forest soils: a review. Oecologia, ***143***: 1–10.

Chromek I. (2006): História a definovanie lesných požiarov. [History and definition of forest fires.] In: Lesné požiare: aktuálne nebezpečenstvo v jarných a letných mesiacoch. Zborník referátov z odborného seminára. Zvolen, 22. March 2006. Zvolen, Technická univerzita vo Zvolene: 6–14.

Evans W.G. (2010): Reproductive role of infrared radiation sensors of *Melanophila acuminata* (Coleoptera: Buprestidae) at forest fires. Annals of the Entomological Society of America, ***103***: 823–826.

Felix Z. (1948): Požární ochrana lesů. [Fire forest protection.] Hasič, ***6***: 1–100.

Hodr J. (1963): Požární ochrana v zemědělství a lesním hospodářství. [Fire Protection in Agriculture and Forestry.] Praha, SZN: 378.

Kubíček F., Šomšák L. (1982): The herb layer production of fir forests in the eastern part of the Slovenské rudohorie Mts. Biologické práce (Bratislava), ***28***: 59–178.

Kula E. (1980): Die Waldbrände in der ČSSR. Tharandt-Brno, Sb. Kolloquium: 34–36.

Kula E. (1981a): Lesní požáry v ČSSR. [Forest fires in the CSSR.] Lesnictví, ***27***: 545–566.

Kula E. (1981b): Výskyt a příčiny lesních požárů v ČSR v letech 1974 až 1978. [Occurrence and cause of forest fires in the Czech Republic 1974–1978.] Lesnická práce, ***59***: 75–82.

Kula E. (1981c): Výskyt a příčiny lesních požárů v SSR v letech 1974 až 1978. [Occurrence and cause of forest fires in the Slovak Republic 1974–1978.] Les, ***37***: 113–116.

Kula E. (1985a): Charakteristika požárů v lesním hospodářství. [Characteristic of fires in forestry.] Lesnická práce, ***63***: 548–554.

Kula E. (1985b): Výskyt a příčiny lesních požárů v ČSSR (1979–1983). [Occurrence and reasons of forest fires in Czechoslovakia 1979–1983.] Acta Universitatis Agriculturae, ***54***: 225–246.

Kula E., Ząbecki W. (1997a): Blesk a kůrovcová ohniska. [Lightning and barkbeetle focus.] Lesnická práce, ***76***: 254–255.

Kula E., Ząbecki W. (1997b): Pogromiska przyczyną powstawania gniazd kornikowych w drzewostanach świerkowych. [Lightning-stroken areas as the centres of bark-beetle-infested patches within spruce stands.] Sylwan, ***141***: 89–97.

Kunt A. (1967): Lesní požáry. [Forest Fires.] Praha, Československý svaz požární ochrany: 313.

Li L., Cheng S., Yue D., Zhou Y. (2010): Forest fire smoke long-distance transport track analysis and its impacts on air quality. In: 18th International Conference on Geoinformatics. Beijing, 18. June 2010. Beijing, Institute of Electrical and Electronics Engineers: 569–572.

Nechleba A. (1927): Ochrana proti ohni. [Protection agains fire.] Háj, ***4***: 191–198.

Pfeffer A. (1938): Lesní požáry v Československé republice v r. 1934. [Forest Fires in Czechoslovakia in 1934]. Písek, Československá matice lesnická: 43.

Pfeffer A. (1961): Ochrana lesů. [Forest Protection.] Praha, SZN: 838.

Šomšák L., Dlapa P., Kollár J., Kubíček F., Šimonovič V., Janitor A., Kanka R., Šimkovic I. (2009): Fire impact on the secondary pine forest and soil in the Borská nížina lowland (SW Slovakia). Ekologia (Bratislava), ***28***: 52–65.

Received for publication May 25, 2012
Accepted after corrections December 12, 2012

Corresponding author:
Prof. Ing. Emanuel Kula, CSc., Mendel University in Brno, Faculty of Forestry and Wood Technology, Department of Forest Management, Zemědělská 3, 613 00 Brno, Czech Republic
e-mail: kula@mendelu.cz