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Fire Data

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Synonyms

Fire occurrence; Fire records; Fire reporting; Fire statistics; Fire trends

Definition

Information collected on fire events and their consequences. These data are often used to characterize patterns of fire occurrence, fire causes, area burned, and impacts to populations, resources, and assets at various scales. Spatial and temporal patterns of fire activity can be characterized to support wildland/wildland-urban interface (WUI) fire research, education, and management efforts (e.g., risk assessment and mitigation, fire prevention, preparedness, suppression).

Introduction

The statistical analysis of wildland fire activity is integral to wildland fire planning, operations, and research across the globe. Historical fire records are inputs to fire danger rating applications, fire-potential forecast models, geospatial fire modeling systems, and other tools for risk assessment, planning, budgeting, and decision support at multiple scales (Manzello et al. 2018). Spatiotemporal analyses of wildfire activity are used to characterize patterns and trends in relation to potential drivers such as population, land use, climate, and fire-control policies and to understand the socio-ecological impacts of fire (Doerr and Santín 2016; Andela et al. 2017; Manzello et al. 2018; Riley et al. 2019).

At a global scale, data on the timing and extent of biomass burning in recent decades can be derived from satellite observations, and several remote-sensing initiatives have been developed to better understand the role of landscape fire in the global carbon cycle (e.g., Schultz et al. 2008; Giglio et al. 2013). Analysis of multiple satellite datasets indicates that global burned area decreased by nearly 25% over the period 1998–2015, largely driven by land-use changes (i.e., less intentional burning) in non-forested areas of South America, Africa, and the Asian steppe (Andela et al. 2017). While global burned area has declined over recent decades, fire-weather seasons have lengthened across nearly a quarter of the Earth's vegetated surface during the period 1979–2013, with significant trends observed for

S. L. Manzello (ed.), *Encyclopedia of Wildfires and Wildland-Urban Interface (WUI) Fires*,
https://doi.org/10.1007/978-3-319-51727-8_112-1

all vegetated continents except Australia/New Zealand (Jolly et al. 2015).

In many countries, satellite data are augmented by national, state, and local wildland fire statistics from archival summary reports and incident-level documentary fire records that can be used for regional and subregional analyses. For example, Jolly et al. (2015) used data from national reporting systems to demonstrate that inter-annual variations in fire-weather season length over recent decades were significantly correlated with inter-annual variations in burned area across North America and the European countries of France, Greece, Italy, Latvia, Portugal, and Spain. As with the work of Jolly et al. (2015), analyses based on archival summary reports and documentary fire records are generally constrained to fire-prone regions that tend to have the most available and consistently reported data, including Australia, Mediterranean Europe, and the USA (Doerr and Santín 2016).

This contribution provides an overview of the available wildland fire data and some reported patterns and trends in wildland fire activity (e.g., fire numbers, area burned) for Australasia (i.e., Australia and New Zealand), Europe, and the USA.

Fire Data and Statistics in Australasia

Neither Australia nor New Zealand has a federal fire agency that collects fire data. Each state and territory collects data independently, and only limited data are available on every state and territory. This section presents a summary of the information available across Australia and New Zealand and then focus on the state of Victoria, Australia.

Fire Trends in Australasia

Table 1 presents the estimated area burned in Australia and New Zealand in recent decades. The states and territories with the greatest burnt areas are Western Australia (WA), Northern Territory (NT), and Queensland (QLD). This is primarily because they are the largest states and territories. Much of northern Australia is a savanna environment, and on average approximately 30% of this area burns annually (Harris et al. 2008). The southeastern states (Victoria [VIC], New South Wales [NSW], South Australia [SA], and Tasmania [TAS]) have less burned area but are well-known for high-impacting fires (Gill and Cary 2012). This is due to the combination of available fuel to burn, population residing within or on the edge of vegetated regions, and the unique climate of the region. It experiences a “Mediterranean-like” climate, with hot, dry summers and mild, wet winters (Lucas et al. 2007), and its topography allows hot, very dry continental air to be advected over the state ahead of the dry cold fronts that are a feature of its summertime climate. These conditions can be further exacerbated by periodic drought (Lucas et al. 2007).

New Zealand has a relatively low fire frequency, and fires are rarely as destructive as those experienced in Australia (Manzello et al. 2018). There are, on average, 4000 ha burned each year for the period 2006–2016 across New Zealand (Table 1).

Data Sources in Victoria

Many of the states and territories have more than one agency collecting fire data. Often the collection and recording practices differ. The Department of Environment, Land, Water and Planning (DELWP) is responsible for the management of fires on public land in Victoria. DELWP maintain a dataset of reported bushfire ignitions and areas burned since 1972. This dataset includes information such as start date, latitude and longitude at the point of ignition (or first reported position), and an estimate for the area burned for all fires reported to DELWP in Victoria. The Country Fire Authority (CFA) is responsible for fires originating on private land. They also maintain a database that includes information on the start time and location of the fire, and this database extends back to 1998. An estimate of the area burned is also recorded but not in all cases.

Fire Data, Table 1 Estimated area burned in Australia (by state or territory) in hectares. (From Manzello et al. 2018)

	Australia							New Zealand[f]
	NSW[a,f,g]	NT[a,f]	QLD[a,f]	SA[a,f]	TAS[b,f]	VIC[c,f]	WA[d,f]	
2006–2007	352,000	3,899,000	3,480,000	353,000	125,000	1,207,899	1,945,633	4099
2007–2008	51,000	2,583,000	2,125,000	500,000	31,600	28,396	1,425,806	9082
2008–2009	23,000	2,031,000	2,013,000	33,000	5890	446,244	1,740,000	2363
2009–2010	160,000	2,712,000	5,149,000	15,000	15,800	24,166	2,602,767	5254
2010–2011	2000	1,245,000	450,000	137,000	1479	13,524	645,505	2920
2011–2012	82,807	No data	No data	No data	9350	3976	4,991,503	1495
2012–2013	1,209,515	No data	No data	No data	69,017	200,455	5,477,394	4362
2013–2014	510,828	No data	No data	No data	7512	415,107	2,209,619	2051
2014–2015	183,677	No data	No data	No data	6848	53,875	2,569,695	4651
2015–2016	87,810	No data	No data	No data	143,500	25,345	1,887,954	3508
2016–2017	268,367	No data	No data	No data	34,576	No data	1,062,958	No data
2017–2018	259,720	No data	No data	No data	No data	No data	2,780,972	No data

Data sources: [a]State of environment report SOE, [b]Tasmanian forest service, [c]Country Fire Authority, [d]Department of Biodiversity, Conservation and Attractions, [e]New South Wales Rural Fire Service, [f]Manzello et al. (2018)

Fire Trends and Variability in Victoria

Number of Fires and Area Burned

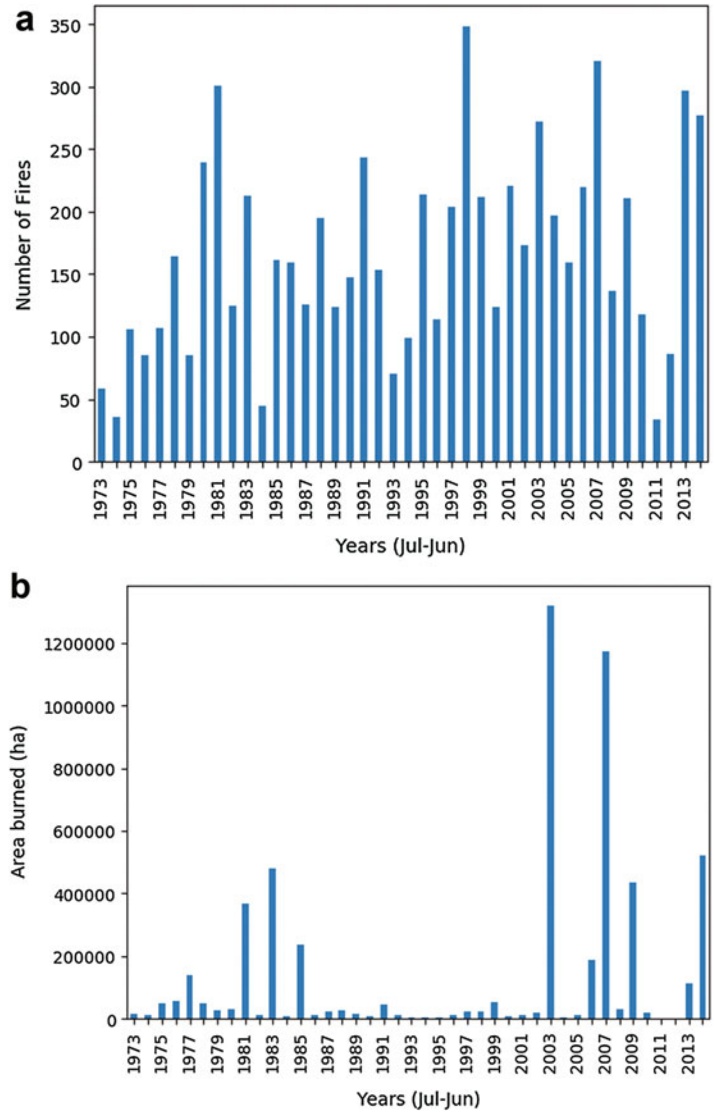
Based on the DELWP data (primarily focused on fires occurring on public land), excluding prescribed burns, there is large inter-annual variability in the total number of fires that occur each fire season although the average number of fires has been increasing (Fig. 1a). For the study period of 1972–1973 to 2013–2014, the mean annual number of fires is 353, with a standard deviation of 182. The maximum annual number of fires is 805 (in 1997/98), and the minimum number of fires is 65 (in 2010/11) (Harris et al. 2019).

There is also large inter-annual variability in area burned each fire season (Fig. 1b). Fire seasons with over 100,000 ha burned include 1976–1977, 1980–1981, 1982–1983, 1984–1985, 2002–2003, 2006–2007, 2008–2009, 2012–2013, and 2013–2014 with 2002–2003 and 2006–2007 burning over 1,000,000 ha. The seasons with the least area burned (<1000 ha burned) include 1992–1993 and 2010–2011 (Harris et al. 2019).

The most active month for fire ignitions in Victoria based on the DELWP data (Phan and Kilinc 2015) is January (over 140 on average) followed by February and then December (Fig. 2). As expected June and July (winter months) have the fewest recorded ignitions. The most active months for prescribed burning and burning off are in March, April, October, November, and December – all with less than a mean number of fires of 15. For area burnt the largest areas on average burnt occur in January, December, and then February.

Consequences

Gill et al. (2013) and Gill and Cary (2012) suggest that Southeast Australia is one of the worst regions globally for socially disastrous fires. This is because bushfires in the southeast Australian state of Victoria have contributed to over 67% of all bushfire-related deaths that have occurred in Australia over the last 110 years (Blanchi et al. 2014). Victoria has experienced some of the most destructive Australian fires in the last century, including Black Friday in 1939, Ash Wednesday in 1983, and more recently Black Saturday in 2009 that resulted in the loss of 173 human lives and destroyed over 2000 homes (Teague et al. 2010). The average annual economic cost of bushfires in Australia is $1.1 billion per year (Deloitte 2017).



Fire Data, Fig. 1 Annual (Jul–Jun) a. number of fires and b. area burned based on DELWP data for 1972–2014. (Phan and Kilinc 2015, used in Harris et al. 2019)

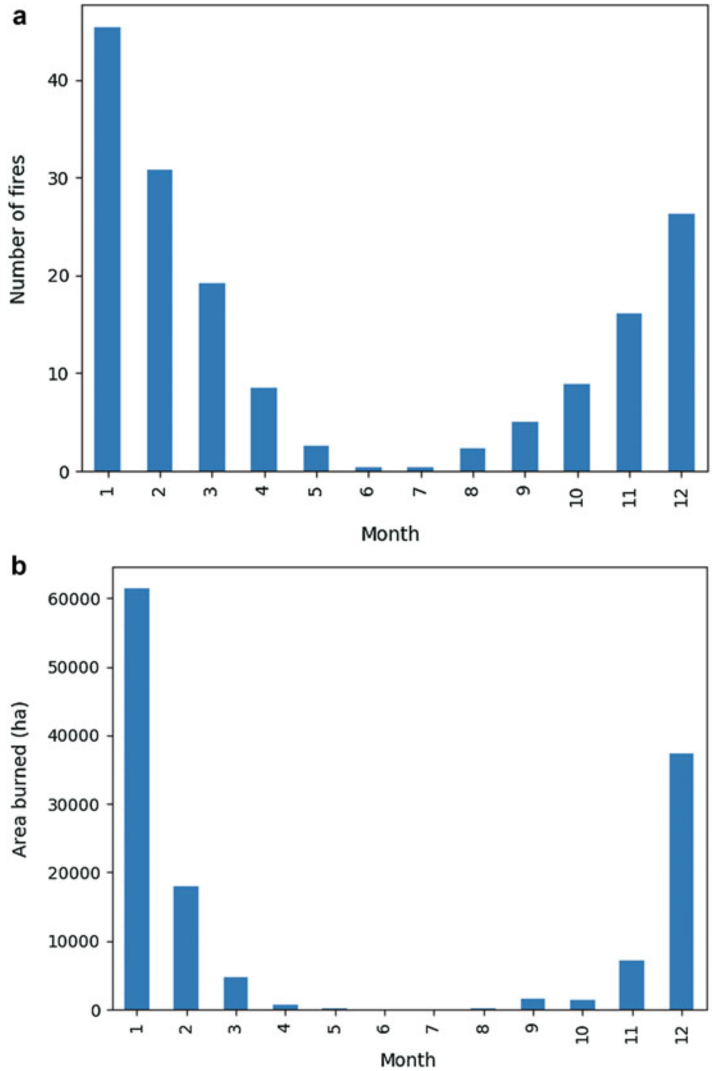
Fire Data and Statistics in Europe

Data Sources

Fire data are collected by national fire administrations at the national level in order to provide a comprehensive view of the situation as regards to wildfires in the country. However, often fire management is the responsibility of subnational administrations at the state or autonomous community level. These subnational administrations provide the data to the national administration to compile national fire statistics. It is assumed that quality control is established in the national collection systems, although information for each of these is not currently available.

At a higher level of abstraction, the European Forest Fire Information System (EFFIS) of the European Commission Joint Research Centre collects national data to compile statistics at the pan-European level. Although the definitions and systems in the countries are different, an agreement was established for the collection of a common core of fire information at European level, which is transmitted by the national administrations to EFFIS. Currently, 26 out of the 42 countries in the EFFIS network, covering

Fire Data, Fig. 2 Mean monthly a. number of fires and b. area burned based on DELWP data for 1972–2014. (Phan and Kilinc 2015, used in Harris et al. 2019)



Europe, North Africa, and Middle East countries, provide detailed fire data records to the EFFIS database. The collection of ground data is costly and, in some countries, just not feasible, given the division of responsibilities regarding fire management among the different national administrations. Quality control and consistency checks are established in EFFIS prior to the inclusion of the individual fire records provided by countries in the EFFIS Fire Database (Camia et al. 2014).

Since 2000, in addition to the data provided by the national fire administrations to EFFIS, data on the number of fires of approximately 30 ha and larger and the area burned by these is produced from remote-sensing sources by EFFIS (San-Miguel-Ayanz et al. 2012). EFFIS data serves as complementary data to those produced by national administrations and fills the gap for those countries that do not have a data collection system in place.

Fire data and statistics from both of the abovementioned data collection systems are published annually by the European Commission and the national administrations in the annual “Forest Fires in Europe, Middle East and North Africa” reports. These reports include individual chapters of the national reporting systems as well as European-wide fire statistics and act as a reference as regards fire monitoring in the extended Pan-European region. The most recent of these reports includes the national reporting of 29 countries in Europe and 4 countries in the Middle East and North Africa (San-Miguel-Ayanz et al. 2018).

Fire Trends and Variability

About half a million hectares of natural land are burnt every year in the European Union (EU) by about 50,000 fires, which are mainly caused by human actions (Gantaume et al. 2012). However, the compilation of European statistics is a complex issue, as not all the countries in Europe have data collection systems in place. Additionally, within those that collect fire statistics, the time series for which data are available in each country are highly variable. The longest time series in European countries are those of the Mediterranean countries, which go back to the 1980s. National data series are often reported in the annual country reports, which include country totals for most countries. The latest of these is the "Forest Fires in Europe, Middle East and North Africa 2017" report (San-Miguel-Ayanz et al. 2018).

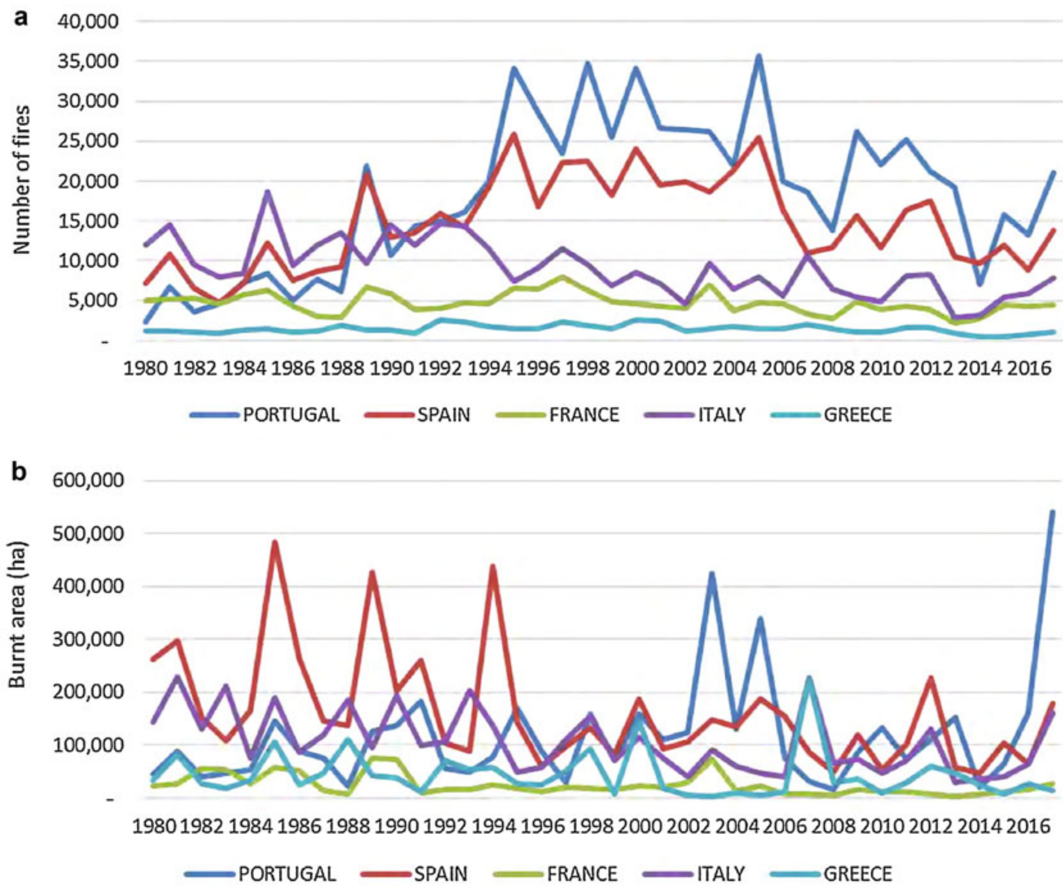
About 85% of the burned area in Europe occurs in the EU Mediterranean regions within Portugal, Spain, France, Italy, and Greece. Table 2 and Fig. 3 present the situation in these countries in the last 37 years. Figure 3(a) below shows a decreasing trend in the number of fires after the 1990s, with high variability among countries. In terms of burnt areas, the most noticeable fact is the high inter-annual variability in the countries during the last decade, despite the high increase in firefighting means in these countries since the 1990s. Critical fire seasons were those of 2003, 2005, and 2017 in Portugal, 2007 in Italy and Greece, and 2012 in Spain and the 2017 season in the whole European region; over 1.3 million ha were burnt in the EU countries that year (Fig. 3b).

For other countries that are not included in the above statistics, the annual number of fires and burned area is provided in Tables 3 and 4, respectively. There are no significant trends of either number of fires or burnt areas in these

Fire Data, Table 2 Number of fires and burnt area in the five southern countries of the European Union

Number of fires	Portugal	Spain	France	Italy[(a)]	Greece[(a)]	Total
2017	**21 002**	**13 793**	**4 403**	**7 855**	**1 083**	**48 136**
% of total in 2017	44%	29%	9%	16%	2%	100%
Average 1980–1989	7 381	9 515	4 910	11 575	1 264	34 645
Average 1990–1999	22 250	18 157	5 538	11 164	1 748	58 851
Average 2000–2009	24 949	18 369	4 418	7 259	1 695	56 690
Average 2010–2017	18 112	12 572	3 776	5 828	1 001	41 289
Average 1980–2017	18 176	14 761	4 707	9 121	1 449	48 215
Total (1980–2017)	690 700	560 928	178 865	346 602	55 066	1 832 161
Burnt areas (ha)	Portugal	Spain	France	Italy[(a)]	Greece	Total
2017	**540 630**	**178 234**	**26 378**	**137 103**	**13 393**	**895 738**
% of total in 2017	59%	19%	3%	18%	1%	100%
Average 1980–1989	73 484	244 788	39 157	147 150	52 417	556 995
Average 1990–1999	102 203	161 319	22 735	118 573	44 108	448 938
Average 2000–2009	150 101	127 229	22 362	83 878	49 238	432 809
Average 2010–2017	157 052	104 502	12 019	72 945	27 198	373 715
Average 1980–2017	118 797	162 352	24 702	107 357	44 084	457 293
Total (1980–2017)	4 514 300	5 991 140	938 687	4 079 562	1 675 209	17 377 132

[(a)]Provisional figures



Fire Data, Fig. 3 (**a**) Number of fires and (**b**) burnt areas in the five southern countries of the European Union

countries. It is noticeable that the number of countries providing annual totals on fires has increased in the last years. Figure 4 confirms the lack of significant trends in either number of large fires (>30 ha) or burnt area in the EU28 region; especially notable is the high inter-annual variability of both variables.

Although very detailed in terms of attributes describing fire events, the EFFIS Fire Database is not comprehensive, as it does not include some countries in which data collection systems are not available. For this reason, the above data are complemented by data on number of fires and burnt areas derived by remote sensing in EFFIS. The EFFIS remote-sensing data include only fires above a given size, which is set at around 30 ha or larger, and the time period 2000–2019. The advantage of this later dataset is that it is fully standardized, so that data among countries are fully comparable; also, that it includes a uniform time series for all countries (2000–2019); and finally that it includes all countries in Europe, Middle East, and North Africa (San-Miguel-Ayanz et al. 2019a). Its main drawback is that small fires, which are highly relevant in some countries, are not accounted for. Figure 5 shows the latest values of number of fires per country and burnt areas by land cover type, for 2018. Although, overall, 2018 was a mild year in Europe, it is noticeable how countries that do not report data to EFFIS were also impacted by forest fires. In 2018, the impact of fires in central and northern European countries was high, including in countries like Sweden, Norway, the UK, and Ireland. The impact of fires has been very relevant during the last decade in countries in the Balkan

Fire Data, Table 3 Annual number of fires

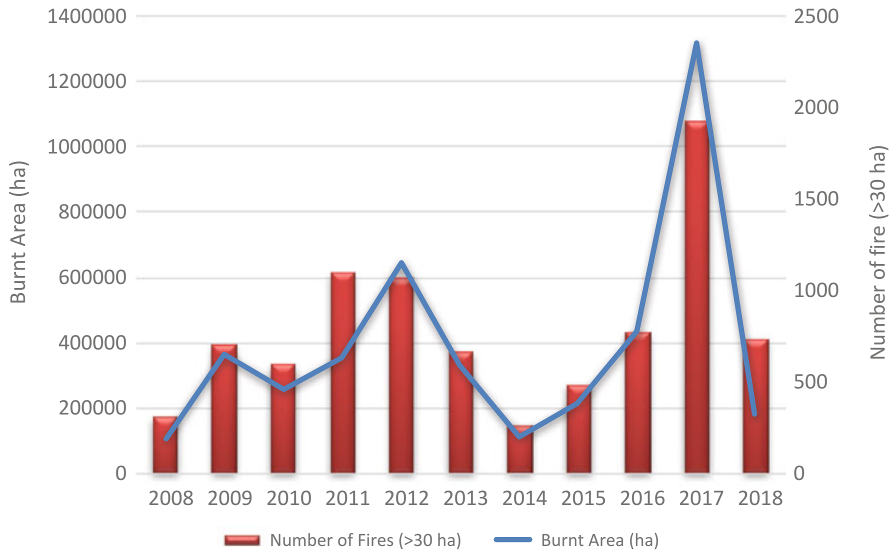
Country	Algeria	Austria	Bulgaria	Croatia	Cyprus	Czech Rep.	Estonia	Finland	Former Yugoslav Republic of Macedonia	Germany	Hungary	Latvia	Lebanon	Lithuania	Morocco	Poland	Norway	Romania	Russian Federation	Slovakia	Slovenia	Sweden	Switzerland	Turkey
Year																								
1990	–	–	–	–	–	–	–	–	–	–	–	604	–	–	179	5756	–	131	–	–	–	–	257	1750
1991	–	–	73	–	–	–	–	–	–	1846	–	225	–	–	247	3528	–	42	–	–	–	–	152	1481
1992	–	–	602	325	–	–	–	–	–	3012	–	1510	–	1180	182	11858	–	187	–	–	–	–	86	2117
1993	–	–	1196	372	–	–	–	–	–	1694	–	965	–	634	187	8821	–	159	–	–	–	–	83	2545
1994	–	–	667	181	–	–	–	–	–	1696	–	763	–	715	417	10705	–	121	–	366	–	–	86	3239
1995	–	–	114	109	–	1331	–	–	–	1237	–	582	–	472	528	7678	–	62	–	254	–	–	96	1770
1996	–	–	246	305	–	1421	–	1475	–	1748	–	1095	–	894	220	7923	–	72	–	662	–	–	130	1645
1997	–	–	200	305	–	1398	–	1585	–	1467	–	768	–	565	391	6817	–	37	–	535	–	–	179	1339
1998	–	–	578	441	–	2563	–	370	–	1032	–	357	–	258	416	6165	–	59	–	1056	–	2503	121	1932
1999	–	–	320	223	–	1402	–	1528	–	1178	229	1196	–	1022	385	9820	–	138	–	426	–	4707	50	2075
2000	–	–	1710	706	285	1499	158	826	–	1210	811	915	–	654	321	12426	–	688	–	824	–	4708	70	2353
2001	–	–	825	299	299	483	91	822	–	587	419	272	–	287	327	4480	117	268	–	311	–	4831	67	2631
2002	–	–	402	176	243	604	356	2546	–	513	382	1720	–	1596	202	10101	213	516	–	570	60	6490	117	1471
2003	–	–	452	532	427	1754	111	1734	–	2524	375	900	–	885	392	17087	198	203	–	872	224	8282	304	2177
2004	–	–	294	204	221	873	89	816	–	626	104	647	–	468	714	7006	119	34	–	153	51	4955	94	1762
2005	–	954	241	147	185	619	65	1069	–	496	150	365	–	301	662	12049	122	64	–	287	73	4573	110	1530
2006	–	912	393	181	172	697	250	3046	–	930	97	1929	–	1545	381	11541	205	105	–	237	112	4618	110	2227

2007	–	750	1479	345	111	805	64	1204	652	779	603	425	–	251	340	8302	65	478	–	463	140	3737	120	2829
2008	–	–	582	275	114	470	71	1456	573	818	502	700	–	301	273	9090	171	91	–	182	74	5420	63	2135
2009	–	218	314	181	91	514	47	1242	80	763	608	823	–	471	501	9162	109	190	–	347	120	4180	104	1793
2010	–	192	222	131	133	732	30	1412	99	780	109	316	–	104	629	4680	62	70	32300	127	32	3120	88	1861
2011	2487	356	635	280	85	1337	24	1215	523	888	2021	360	–	142	606	8172	49	340	20851	303	114	3534	114	1954
2012	5110	312	876	569	78	1549	5	417	483	701	2657	162	–	81	484	9265	24	911	19535	517	168	2213	75	2450
2013	2443	357	408	137	135	666	15	1451	186	515	761	422	–	123	411	4883	42	116	9754	233	75	4878	58	3755
2014	4629	369	151	43	68	865	91	1660	62	429	1042	698	–	155	460	5245	133	83	17058	153	35	4374	60	2149
2015	2383	345	429	177	87	1748	67	745	106	1071	1069	704	107	247	425	12257	29	250	12238	242	93	2700	166	2150
2016	3150	317	584	151	119	892	84	933	60	608	452	641	260	98	422	5286	345	174	10089	136	90	5454	81	3188
2017	2992	265	513	329	92	966	61	881	301	424	1454	423	92	80	433	3592	264	447	10051	162	108	5276	110	2411

Fire Data, Table 4 Annual burnt area (ha)

Country	Algeria	Austria	Bulgaria	Croatia	Cyprus	Czech Rep.	Estonia	Finland	Former Yugoslav Republic of Macedonia	Germany	Hungary	Latvia	Lebanon	Lithuania	Morocco	Poland	Norway	Romania	Russian Federation	Slovakia	Slovenia	Sweden	Switzerland	Turkey
Year																								
1990	–	–	–	–	–	–	–	–	–	–	–	258	–	–	2188	7341	–	444	–	–	–	–	1723	13742
1991	–	–	511	–	–	–	–	–	–	920	–	69	–	–	3965	2567	–	277	–	–	–	–	96	8081
1992			5243	11131	–	–	–	–	–	4908	–	8412	–	769	2579	43755	–	729	–	–	–	–	65	12232
1993	–	–	18164	20157	–	–	–	–	–	1493	–	570	–	274	3078	8290	–	518	–	–	–	–	37	15393
1994	–	–	18100	7936	–	–	–	–	–	1114	–	326	–	279	6072	9325	–	312	–	–	–	–	408	38128
1995	–	–	550	4651	–	403	–	–	–	592	–	535	–	321	7018	5403	–	208	–	–	–	–	446	7676
1996	–	–	906	11214	–	2043	–	433	–	1381	–	927	–	478	1185	14537	–	227	–	–	–	–	293	14922
1997	–	–	595	11122	–	359	–	1146	–	599	–	448	–	226	3845	6766	–	68	–	–	–	–	1785	6316
1998	–	–	6967	32056	–	1132	–	131	–	397	–	211	–	93	1855	4222	–	137	–	–	–	422	274	6764
1999	–	–	8291	6053	–	336	–	609	–	415	756	1544	–	494	1688	8629	–	379	–	557	–	1771	30	5804
2000	–	–	57406	68171	8034	375	684	266	–	581	1595	1341	–	352	4064	7089	–	3607	–	904	–	1552	70	26353
2001	–	–	20152	16169	4830	87	62	187	–	122	–	311	–	113	1806	3466	895	1001	–	305	–	1254	21	7394
2002	–	–	6513	4853	2196	178	2082	590	–	122	1227	2222	–	746	593	5210	221	3536	–	595	161	2626	681	8514
2003	–	–	5000	27091	2349	1236	207	666	–	1315	845	559	–	436	2858	21551	942	762	–	1567	2100	4002	673	6644
2004	–	–	1137	3378	1218	335	379	358	–	274	247	486	–	253	8660	3782	117	123.7	–	157	138	1883	31	4876
2005	–	71	1456	3135	1838	227	87	495	–	183	3531	120	–	51	6198	5713	346	162	–	524	280	1562	67	2821
2006	–	75	3540	4575	1160	53	3096	1617	–	482	625	3387	–	1199	5360	5657	3829	946	–	280	1420	5710	127	7762
2007	–	48	42999	20209	4483	316	292	576	32665	256	4636	272	–	38	1367	2841	128	2529	–	679	128	1090	337	11664

2011	13593	78	6883	15555	1599	337	19	580	17308	214	8055	115	–	293	3460	2678	121	2195	1636232	403	288	945	225	3612
2012	99061	69	12730	24804	2531	634	3	86	10021	269	13978	90	–	20	6695	7235	60	6624	1900000	1683	1006	483	30	10455
2013	13396	165	3314	1999	2835	92	79	461	3027	199	1955	217	–	25	2207	1289	47	421	1416659	270	66	1508	29	11456
2014	43125	192	916	188	669	536	78	881	846	120	4454	591	–	162	1540	2690	770	217	3738207	192	18	14666	46	3117
2015	13010	268	4313	9416	652	344	83	143	1798	526	4730	615	753	71	992	5510	143	1671	2875350	353	65	594	47	3219
2016	18370	398	6340	7100	3205	141	123	310	450	283	974	467	1871	26	2585	1451	1884	675	2419254	175	526	1288	454	9156
2017	53975	30	4569	48543	428	170	33	460	5619	395	4933	265	264	53	2414	1023	525	2459	1459099	295	441	1433	118	11993
2008	–	–	5289	7343	2392	86	1280	830	5915	538	2404	364	–	112	1127	3027	3174	373	–	118	75	6113	68	29749
2009	–	22	2271	2900	885	178	59	576	1307	262	6463	646	–	287	3108	4400	1329	974	–	510	177	1537	60	4679
2010	–	37	6526	1121	2000	205	25	520	737	522	878	92.2	–	21.5	5511	2126	769	206	2300000	192	121	540	27	3317



Fire Data, Fig. 4 Total burnt area and number of fires larger than 30 ha in the European Union countries (EU28)

region, such as Croatia, Albania, Serbia, Kosovo, and Montenegro.

As mentioned above, about 95% of the fires in Europe are caused by human activities, due to either negligence or intentional actions (Ganteaume et al. 2012). In the area of negligence, agriculture and shrub reduction activities are the main causes of the fires, while arson has a great variability within each country and at the European level.

Consequences

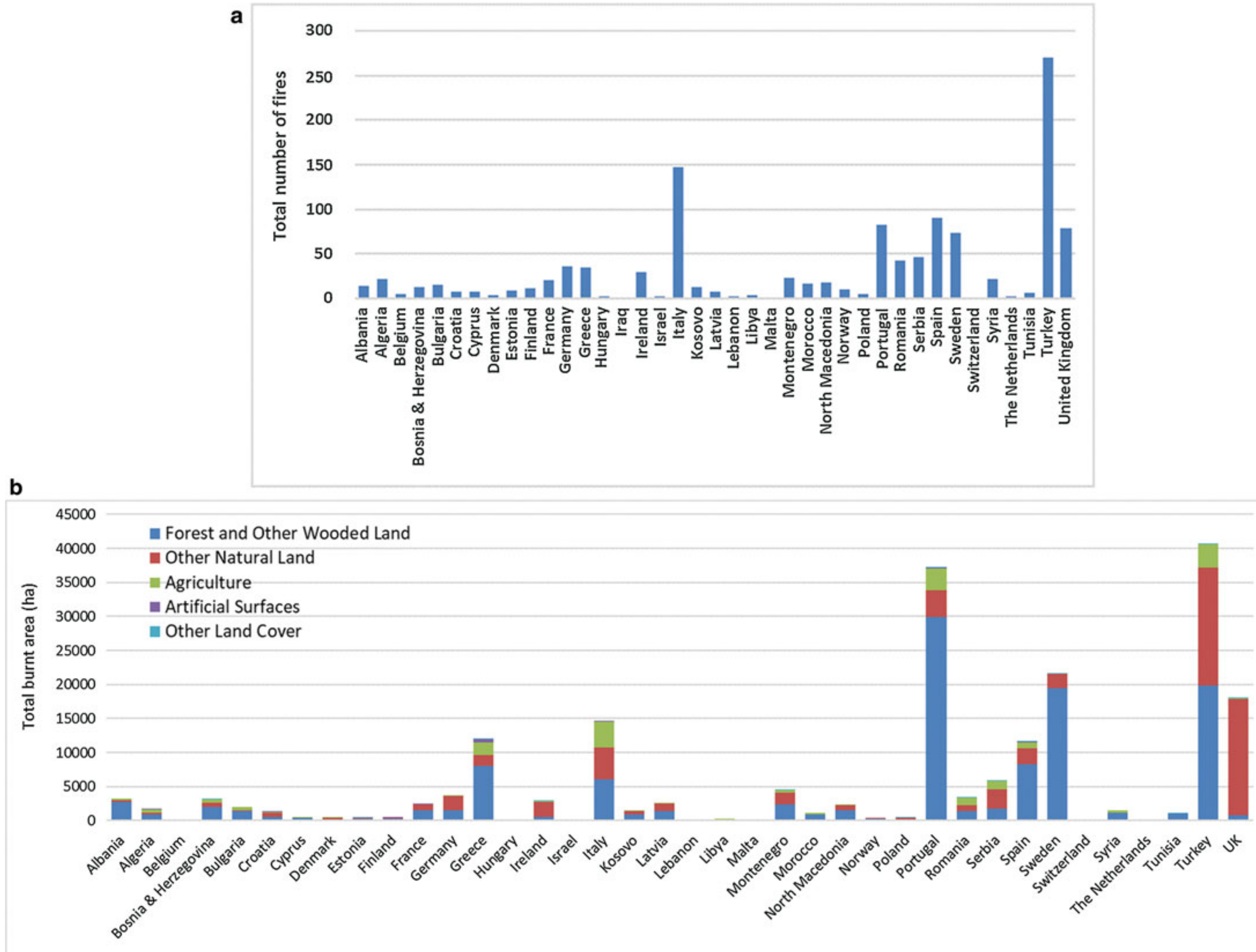
Economic losses at the European level are computed in EFFIS using a simple approximate method of reconstruction cost for the land cover classes that are damaged by fires and taking into consideration the number of fatalities in a given year (San-Miguel-Ayanz et al. 2017). Figure 6 presents the economic losses in the European territory in the last years in millions of Euro.

In terms of casualties, 720 people have been reported killed by forest fire in the EU since the year 2000. The most dramatic wildfire season was that of 2017, in which fires burned approximately 1.3 million ha in the EU, killed 136 people, and resulted in economic losses of around 10 billion euro (San-Miguel-Ayanz et al. 2018). The 2018 fire season, the last year for which data are available, was marked by a dramatic wildfire that took place in the town of Mati, in Greece, killing 100 people (San-Miguel-Ayanz et al. 2019b).

Fire Data and Statistics in the USA

Data Sources

There is no single, unified system of wildland fire record keeping for the USA. The nature of the data collected has typically been a function of the needs and mission of the organizations responsible for fighting these fires. Annual estimates characterizing wildfire activity in terms of total numbers and area burned by the US state are available from the early twentieth century to present (Short 2015). The longest-term estimates are based on archival summary reports that are neither complete nor consistent over the ~100-year period of record (Short 2015). Despite their limitations for long-term analysis due, for example, to marked increases in the reporting area over time (see Houghton et al. 2000; Short 2015), the National Interagency Fire Center (NIFC) currently distributes the national-level estimates in tabular form as on its website https://www.nifc.



Fire Data, Fig. 5 Number of fires (**a**) by country and burnt area (**b**) land cover type, in 2018, estimated by EFFIS

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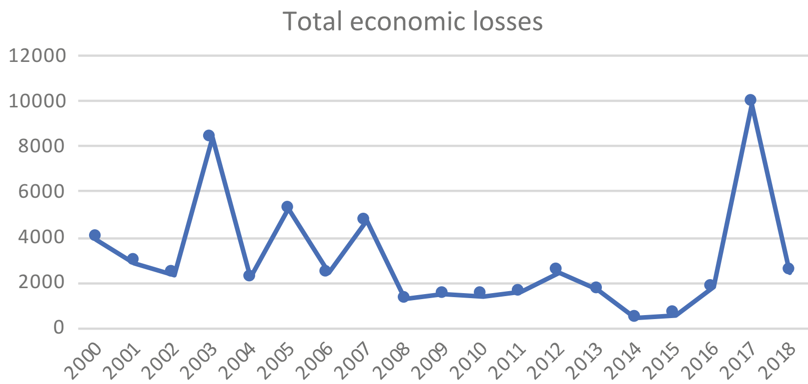

Fire Data, Fig. 6 Economic losses in the European territory in recent years (millions of Euro)

gov/fireInfo/fireInfo_stats_totalFires.html (NIFC 2019). The NIFC (2019) provides little to no information about the data. Short (2015) identified the sources and major limitations of the NIFC-published data, but at the time of that writing, the NIFC only presented wildfire statistics dating back to 1960. Because the NIFC (2019) now includes estimates dating back to 1926, it is important to expand on Short's (2015) caveats to cover the earlier years' data.

In addition to the archival summary reports, there are spatially explicit documentary fire records and remotely sensed data from more recent decades that are generally used for short-term trend analysis at multiple (e.g., regional, national) scales (Short 2015; Murphy et al. 2018). The Landsat-based Monitoring Trends in Burn Severity (MTBS) dataset includes mapped perimeters of large (i.e., >405 ha) wildland fires dating back to 1984 (Eidenshink et al. 2007). In addition, point-based documentary fire records (individual reports of wildfires of all sizes) dating back to 1992 have been compiled from final fire reporting systems of the federal, state, and local fire services and published in the national Fire Program Analysis Fire Occurrence Database (FPA FOD) (Short 2014, 2015, 2017). The local fire department (FD) data in the FPA FOD, which are generally sourced from the National Fire Incident Reporting System (NFIRS) of the US Fire Administration (USFA), are known to be incomplete because different states set their own NFIRS reporting policies for FDs, ranging from mandatory for all incidents to completely voluntary (Short 2014, 2015). The National Fire Protection Association (NFPA) uses their annual FD experience survey combined with NFIRS data to generate a more complete estimate of brush, grass, and forest fires, including many wildland-urban interface (WUI) fires, responded to by FDs (Hall and Harwood 1989; Ahrens 2018).

The National Wildfire Coordinating Group (NWCG) defines a "wildland fire" as "any non-structure fire that occurs in vegetation or natural fuels" and includes both prescribed fire (i.e., planned/controlled burning) and wildfire under the wildland fire umbrella (NWCG 2019). However, the NIFC estimates of "total wildland fires and acres" do not include prescribed fire activity, at least not in recent decades (Short 2015; see next section).

NFIRS has four incident types for "natural vegetation fires" (USFA 2015; Table 5). Estimates of total brush, grass, and forest fires include unclassified or "other" natural vegetation fires. Note that only incident type 141 specifically mentions wildland fire.

Fire Trends and Variability

Area Burned

Prior to widespread Anglo-European settlement, it is estimated that wildland fires burned 35–86 Mha per year from a combination of natural ignitions and indigenous burning practices (Leenhouts 1998; Houghton et al. 2000). The data

Fire Data, Table 5 Incident types representing fires in "natural vegetation" within the National Fire Incident Reporting System (NFIRS), which tracks local fire department responses to fires of all types (USFA 2015)

NFIRS incident type code	NFIRS incident type definition
141	Forest, woods, or wildland fire
142	Brush or brush and grass mixture
143	Grass fire
140	Natural vegetation fire, other

distributed by the NIFC date back to 1926, when the USA had already begun investments in a system of organized wildland fire control, overseen by the US Forest Service (USFS) (Pyne 1982). The USFS archival summary reports, which are the sources of the NIFC statistics from 1926–1982, come from a continuously increasing US land base as the area considered to qualify for inclusion in the federal fire protection program increased over time (Short 2015). The reporting area more than tripled in size from ~200 Mha in 1926 to ~700 Mha in 1983, when it finally reached the total US burnable wildland area (estimated from ca. 2000 data) (Short 2015). Even then, not all of the reporting area was considered protected land under the USFS program requiring the "wildfire activity" statistics. The data are therefore classified as from "protected" versus "unprotected" areas, with the latter published with the caveat, "since no field organizations are established in unprotected areas to report fires, the statistics on such unprotected areas are merely the best estimates by local agencies" (Short 2015).

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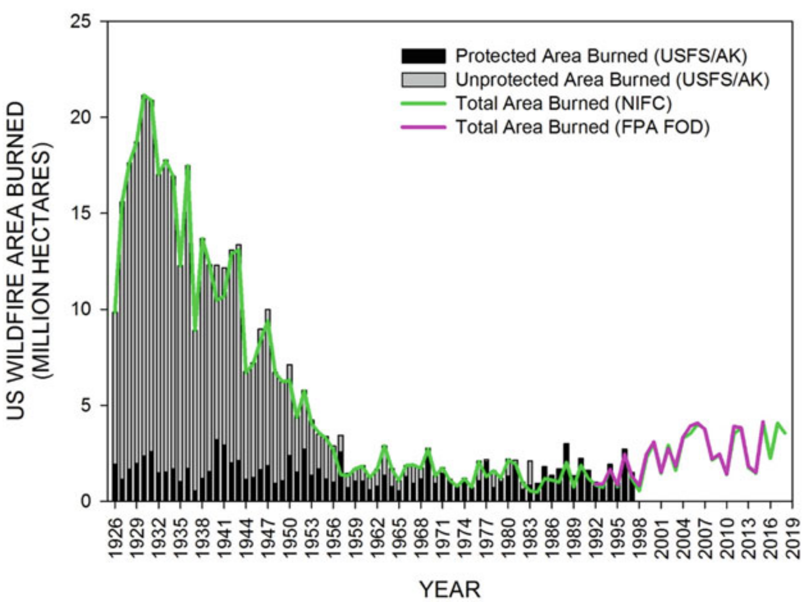
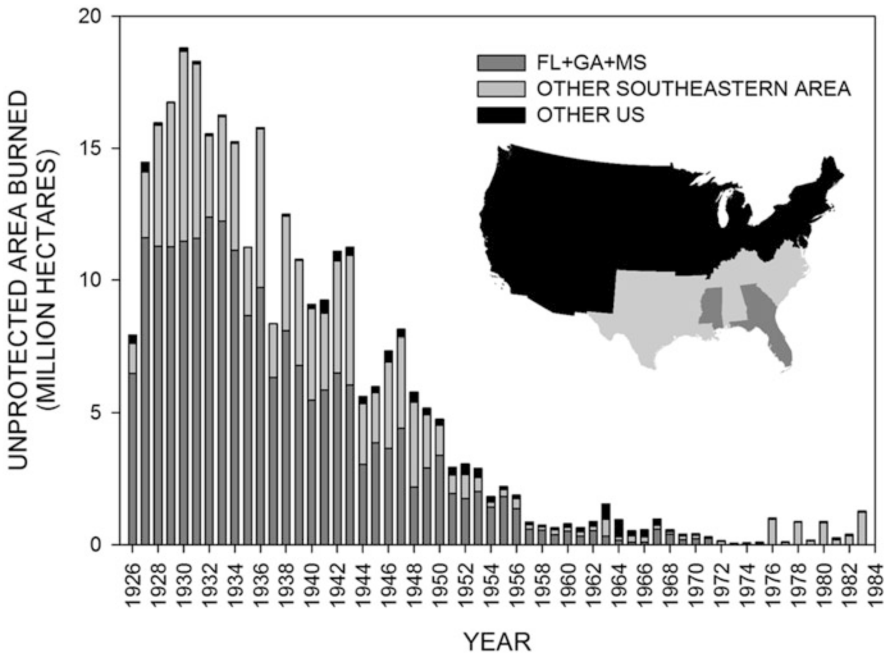
In the early decades of USFS reporting (and, by extension, in the NIFC statistics), the bulk of the estimated area burned is from fires on unprotected lands (Fig. 7). Moreover, nearly all of the unprotected area burned (UAB) resulted from fires in the southern USA, with major contributions from the three states of Florida (FL),



Fire Data, Fig. 7 Wildfire area burned in the USA, 1926–2018. Bars represent estimates from protected (black segments) and unprotected (grey segments) lands as reported in USFS archival summary reports, 1926–1997. The legend refers to these as "USFS/AK" data, because an independent source of area burned estimates for Alaska (Gabriel and Tande 1983) was used to augment the USFS estimates in years that Alaska was excluded from the USFS reports. The green line represents the burned area estimates on the NIFC website (NIFC, 2019). The pink line represents burned area estimates from the FPA FOD, as derived from a compilation of final fire reports from the federal, state, and local fire services for the period 1992–2015 (Short 2014, 2017)

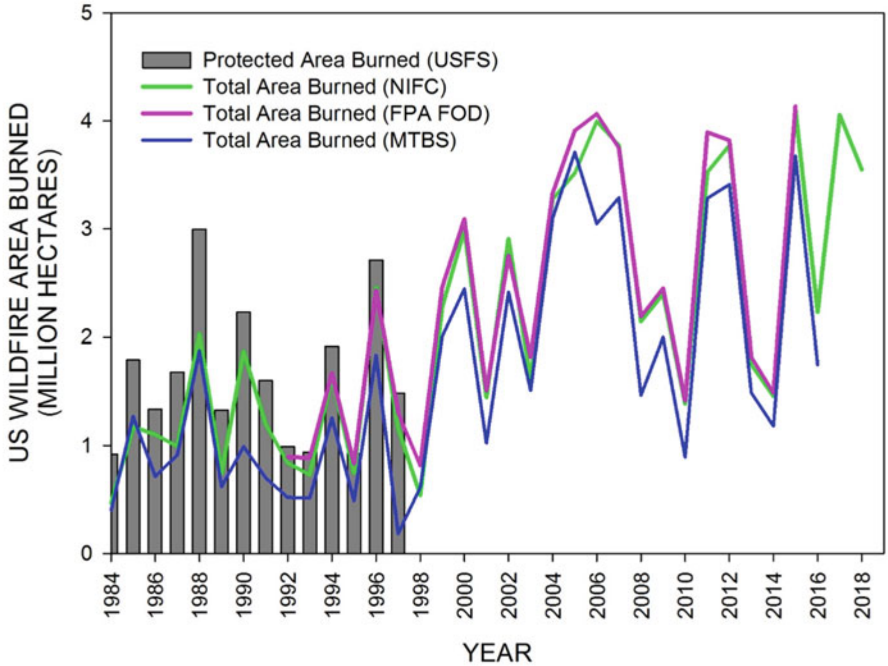


Fire Data, Fig. 8 Wildfire area burned reported from unprotected lands in the USA, 1926–1983. These are the same estimates represented by the grey segments of the bars in Fig. 7, which are sourced from USFS annual summary reports. In early years (e.g., 1926–1949), when estimates exceeded 5 Mha per year, most of the area burned was reported from southeastern states (light and dark gray segments), with an outsized influence from burning in Florida (FL), Georgia (GA), and Mississippi (MS) (dark gray segments)

Georgia (GA), and Mississippi (MS) (Fig. 8). The total UAB estimates exceeded 5 Mha each year from 1926–1949 and reached highs of over 18 Mha in 1930 and 1931 (Fig. 7). At the time, the southeastern USA was known for its woods-burning (Pyne 1982), and intentional burning (later considered prescribed or controlled burning and not included in "wildfire" statistics) under drought conditions is likely the source of those peaks in burned area estimates from the early twentieth century (Short 2015).

Prescribed burning is still widely practiced in the southeastern USA, with estimates of 3–4 Mha burned in each of the 3 years 2011, 2013, and 2017 for forestry or agricultural objectives (Melvin 2012, 2015, 2018). While there are no complete or consistently reported estimates of prescribed burning levels across the USA, several sources indicate that prescribed burning in the southern USA accounts for approximately 70% of the national totals from recent years (Melvin 2015, 2018; Kolden 2019).

In the western USA, land-use change, extirpation of indigenous burning, lack of contemporary prescribed fire use, and aggressive wildfire control measures have effectively excluded wildland fire from many areas that were historically fire-prone and fire-adapted (Leenhouts 1998, Houghton et al. 2000). The magnitude of the decline in burning rates in western forests, for example, is considered on par with "natural" reductions in fire activity during cold, wet climatic intervals in the past (Marlon et al. 2012). However, twentieth-century declines in western forest area burned have occurred under conditions that were and are becoming warmer and drier than those associated with some of the highest estimated burning rates in the past 3000 years, creating a "fire deficit" considered unsustainable given current landscape conditions and trajectory of climate change (Marlon et al. 2012; Parks et al. 2015). Indeed, recent increases in large-fire numbers and wildfire area burned (Fig. 9) have been attributed to fuel accumulations and fire-weather



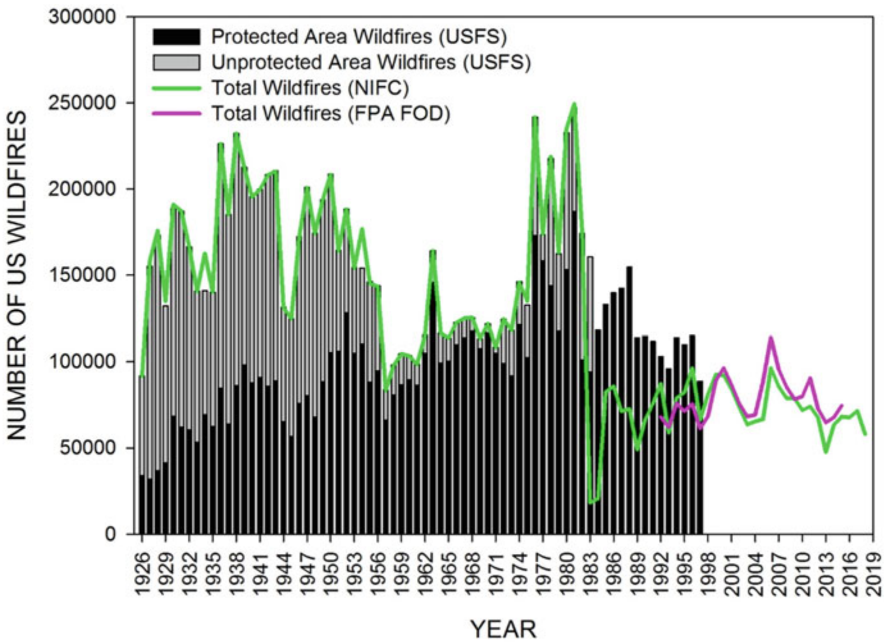
Fire Data, Fig. 9 Wildfire area burned in the USA, 1984–2018, excerpted from Fig. 7, and with MTBS included as a source for 1984–2016. The MTBS estimates are based on a compilation of (Landsat-based) remotely sensed burn scars from large wildfires only (i.e., > = 404 ha in the western USA and > = 202 ha in the East). Empirical data from 1984 to present are most commonly used to assess contemporary trends in US wildfire area burned and large-fire numbers due to the lack of satellite-derived data and reporting biases from the archival summary reports prior to 1984 (Murphy et al. 2018)

conditions that are increasingly conducive to fire spread despite control (suppression) efforts, with most significant upward trends estimated from western ecoregions (Dennison et al. 2014; Freeborn et al. 2016).

In contrast, most of the brush, grass, and forest fires handled by local FDs, 2011–2015, were small, with 60% burning less than 0.4 ha and 94% less than 4 ha (Ahrens 2018). Forest, woods, or wildland fires were most likely to spread beyond 0.4 ha (Ahrens 2018).

Overall Wildfire Numbers

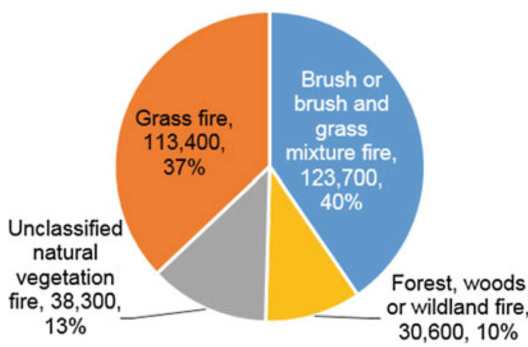
Total wildfire numbers from the USFS annual summary reports ranged from ~64,000 to 250,000 during the period of record 1926–1997, with estimates from protected lands generally increasing with the increasing reporting area (Fig. 10). The peak estimate of ~250,000 fires (from protected and unprotected lands combined) comes from the USFS report for 1981 but then drops back down to around 160,000 in 1983, when the reporting area is estimated to have reached present-day burnable-wildland levels. The NIFC numbers are sourced from USFS annual summary reports for 1926–1982 and then from national situation reporting from 1983 to 2018. During the period of overlap post-1982, estimates from NIFC and the FPA FOD are consistently lower than the USFS numbers, with the greatest discrepancy in the first 2 years of situation reporting, when the NIFC estimate is only ~20,000 wildfires per year. Since ca. 2000, the NIFC and FPA FOD wildfire numbers generally align well, with an average of about 75,000–85,000 per year. At the national level, there have been no published trends in total wildfire numbers that adequately account for reporting discrepancies among sources, including the extent to which each account for fires only responded to by FDs. For the period 2011–2015, the NFPA estimated that FDs responded to an



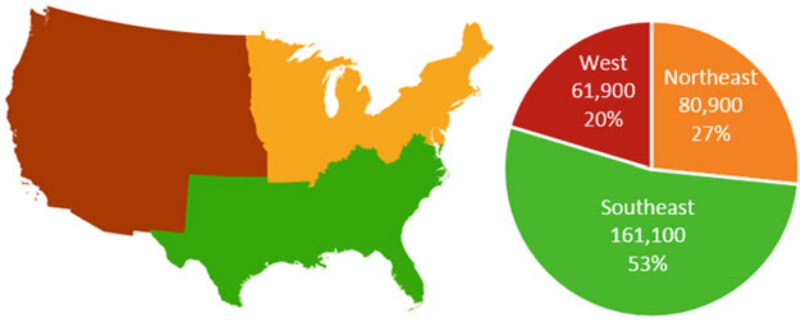
Fire Data, Fig. 10 Wildfire numbers in the USA, 1926–2018. Bars represent estimates from protected (black segments) and unprotected (grey segments) lands as reported in USFS archival summary reports, 1926–1997. The green line represents the wildfire numbers from the NIFC website (NIFC 2019). (Discrepancies between the NIFC and USFS estimates in 1934 and 1954 are due to NIFC capturing the total wildfire numbers from an erroneous section of the USFS reports for those years.) The pink line represents wildfire numbers from the FPA FOD. (Short 2014, 2017)

average of ~300,000 brush, grass, and forest fires in the USA (Ahrens 2018), most of which would not be included in the NIFC or FPA FOD statistics due to the way that the NFPA estimates are derived (i.e., a combination of empirical data and survey responses). Seventy-seven percent of the estimated annual FD responses were to grass fires or to fires in a brush or brush and grass mixture (Fig. 11). Of the fires responded to by FDs, 2011–2015, 53%, 27%, and 20% were located in the southeastern, northeastern, and western regions of the USA, respectively (Ahrens 2018; Fig. 12). Because so much of land in the West is under the jurisdiction of the federal fire service (Vincent et al. 2017), local fire departments generally do not respond to these fires.

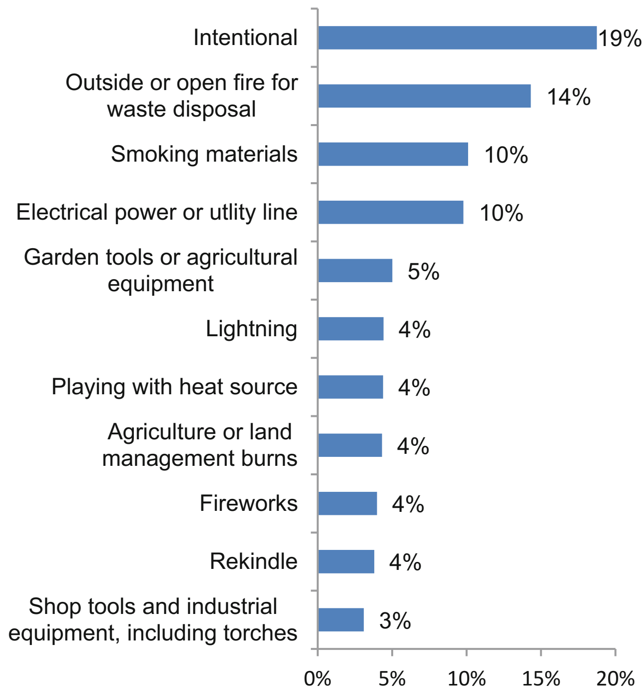
Half of the FD response fires in the Northeast were categorized as brush or brush and grass fires, while one-quarter were grass fires. The Southeast and West had more grass fires (42%



Fire Data, Fig. 11 Estimated annual numbers of brush, grass, and forest fires, by incident type, responded to by local fire departments, 2011–2015. Estimates were derived from the US Fire Administration's National Fire Incident Reporting System and the annual fire department experience survey conducted by the National Fire Protection Association (Ahrens 2018). (Reproduced with permission of NFPA from *Brush, Grass and Forest Fires*. Copyright © 2018, National Fire Protection Association, Quincy, MA. All rights reserved)



Fire Data, Fig. 12 Annual average number of local fire department responses to brush, grass, and forest fires by US region, 2011–2015 (Ahrens 2018). Not included in the map are the states of Alaska (part of West), Hawaii (West), and Puerto Rico (Southeast). (Reproduced with permission of NFPA from *Brush, Grass and Forest Fires*. Copyright © 2018, National Fire Protection Association, Quincy, MA. All rights reserved)

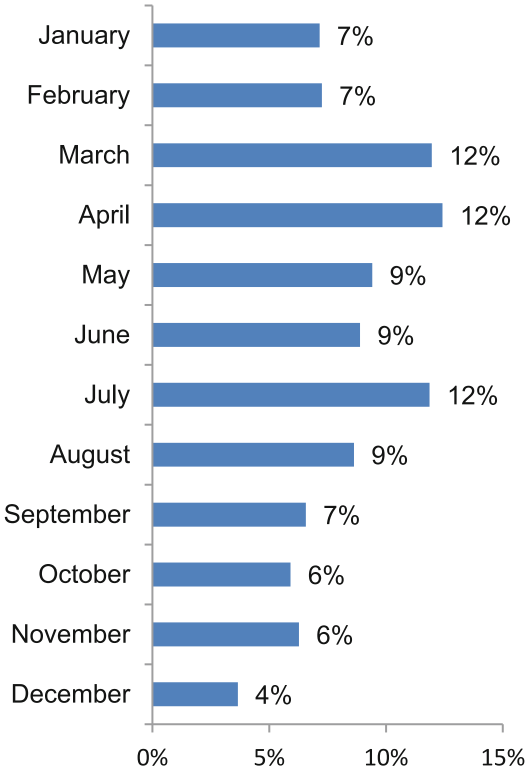


Fire Data, Fig. 13 Breakdown of local fire department responses to brush, grass, and forest fires, 2011–2015, by cause. Unclassified natural vegetation fires are also included. There is some overlap and double counting in these statistics. For example, some firework fires were also included in playing with heat source. Some intentional fires were also considered playing. Some of the open burning fires were also considered intentional (Ahrens 2018). (Reproduced with permission of NFPA from *Brush, Grass and Forest Fires*. Copyright © 2018, National Fire Protection Association, Quincy, MA. All rights reserved)

and 39%, respectively) responded to by FDs than brush or brush and grass fires (37% and 36%, respectively) (Ahrens 2018).

Fire Causes

Fires in the USA have been largely human-caused for centuries (Pyne 1982; Houghton et al. 2000). A recent assessment of the FPA FOD records for 1992–2012 found that humans were the sources of 84% of the ignitions and 44% of the total area burned in the conterminous USA (Balch et al. 2017). Fires responded to by local FDs tend to skew even further toward human-caused, with lightning accounting for only 4% of FD-reported fires. One in five of these local FD fires were intentionally set. Some purposeful fire uses, such as open burning of waste and agriculture burns, spread out of control (Ahrens 2018; Fig. 13). Although not a fire cause per se, high winds were contributing factors in 14% of the locally handled



Fire Data, Fig. 14 Breakdown of local FD responses to brush, grass, and forest fires 2011–2015, by month (Ahrens 2018). (Reproduced with permission of NFPA from *Brush, Grass and Forest Fires*. Copyright © 2018, National Fire Protection Association, Quincy, MA. All rights reserved)

fires (Ahrens 2018). Fires caused by lightning or other natural sources are dominant primarily in sparsely populated, montane regions of the western USA (Balch et al. 2017). While remote lightning-caused fires can grow large and account for a great deal of burned area in the western USA, many recent high-loss events (i.e., fatality and other high-cost fires) in California, for example, have been caused by human activities, including failures of power-transmission infrastructure during high-wind events (Cal Fire 2019).

Analysis of the FPA FOD indicated that 78% of lightning-caused fires during the period 1992–2012 were ignited in the summer (June–August) (Balch et al. 2017). Over that same period, human-caused wildfires were more evenly distributed throughout the year, with 38% igniting in spring, 24% in summer, 19% in fall, and 19% in winter (Balch et al. 2017). Due to the prevalence of fireworks use on the July Fourth Independence Day holiday, human-caused ignitions are most prevalent on that day of year. Similarly, the majority-human-caused grass, brush, and forest fires responded to by local FDs during the period 2011–2015 were most common in early spring months and in July (Ahrens 2018; Fig. 14). Nearly two-thirds (64%) of the brush, grass, and forest fires handled by local FDs that were started by fireworks occurred in July. Seventy percent of the locally handled fires started by lightning occurred June–August (Ahrens 2018).

Consequences

First introduced in 1953, Major Disaster Declarations have been issued for fires in 14 US states (FEMA 2019). They are most commonplace in the state of California, where impacts in terms of property destruction culminated in 2017 and 2018, when insured losses reached $13 billion in back-to-back years (CDI 2019; Folkman 2019). The level of devastation from these recent events is largely associated with massive increases in development in and near California wildlands. The worst of these WUI fire disasters to date was the 2018 Camp Fire, when a wind-driven wildfire grew to 40,000 ha in its first 2 days, engulfing the forested town of Paradise, California. With limited points of egress from the ridgetop town, the extremely fast-moving fire not only destroyed 80 percent of the town's buildings but also claimed 85 lives, many of whom were trapped in their vehicles as they tried to evacuate.

Summary

In many countries around the globe, particularly in fire-prone regions, there is a growing archive of annual summary reports, incident-level documentary fire records, and remotely sensed data that can be used for analyses of wildland fire activity at multiple scales. However, analysts must be cognizant of reporting biases, inconsistencies, and uncertainty in the data in order to maximize the integrity and utility of their work. In several regions, including the USA and the EU, there are national efforts to integrate the disparate reporting systems used by different fire management agencies, which should improve analytical capabilities moving forward (see National Systems Collecting Data on Fire contribution). Wildland fire science and management in other regions (i.e., Africa, Asia, Australasia, South America) could be advanced with similar efforts to collect and consolidate a standard core set of fire-occurrence data within and among various fire management agencies (Manzello et al. 2018). As also pointed out in the contribution on National Systems on Collection Data on Fire in this encyclopedia, much more effort is required to also provide data for WUI fires, as WUI fires occur where the wildlands encroach on the built environment.

Cross-References

- ► Ignition Sources
- ► National Systems Collecting Data on Fire
- ► Wildfires and WUI Fires Fatalities

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