European Commission (EC),
GOFC GOLD Fire Implementation Team (GOFC Fire IT)

Fire Danger Enhancement and Calibration

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Outline

1. Introduction
2. Methodology
3. Results
4. Validation
5. Conclusion

Introduction

- This work was carried out by request of the JRC with the objective of providing a calibration of the Canadian Fire Danger Rating System for the EC countries.
- This calibration had to be applied operationally in the EFFIS System and therefore should be performed automatically by the computer system.

- We used the FWI output of the CFFDRS to assess the risk of having a large number of fire or a large area burned in a given day for area units in the EU territory.
- The FWI is based entirely in meteorological data, but if we use historical data on fire occurrence (number of daily fires and burned area) we can perform a calibration of the system for each area unit.

- This calibration is based on the existence of a monotonic relationship between the two pairs of variables:

$$NF = f_1(FWI) \text{ and}$$
$$BA = f_2(FWI).$$

We checked the validity of these conditions and found that it works better for f1.

FWI & Portuguese Risk Indexes

Our team proposed and applied an original calibration system that was initially developed in collaboration with the Portuguese Institute of Meteorology (IPMA) in 1999 and extended to various other regions.

	FWI Limit Value for each class of fire danger				
	Low	Moderate	High	Very High	Maximum
Viana do Castelo	<10	15	30	45	>45
Braga	<10	15	30	50	>50
Porto	<8	15	25	40	>40
Vila Real	<13	20	30	50	>50
Bragança	<23	30	45	55	>55
Aveiro	<10	17	23	40	>40
Viseu	<15	25	45	70	>70
Guarda	<8	15	25	50	>50
Coimbra	<15	22	30	45	>45
Leiria	<15	25	30	50	>50
C. Branco	<20	35	45	60	>60
Lisboa	<25	35	50	70	>70
Santarém	<25	33	50	60	>60
Setúbal	<30	40	55	70	>70
Portalegre	<35	50	65	75	>75
Évora	<40	50	65	75	>75
Beja	<40	50	65	75	>75
Faro	<30	4	60	75	>75

Tab 1: FWI Calibration for each district of Portugal;
Source: Viegas, et al., 2004

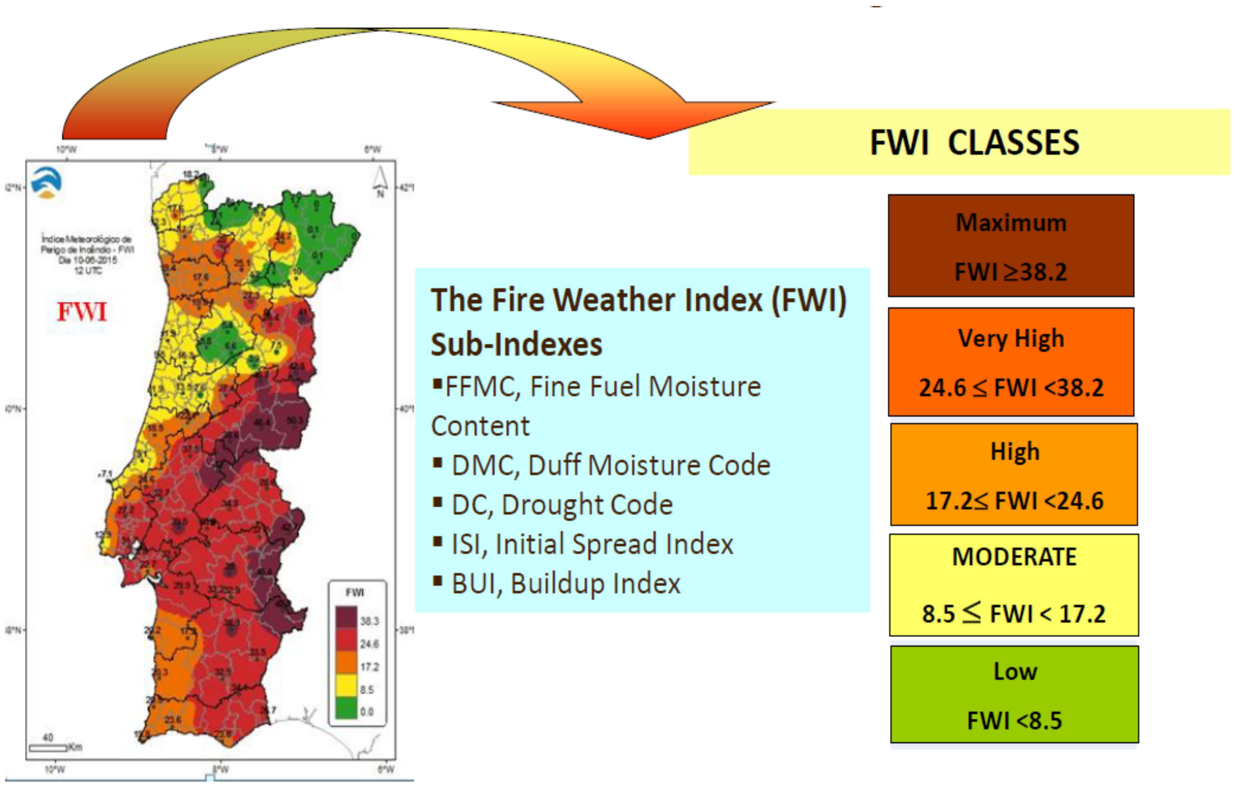


Fig 2: FWI Calibration for the entire Portuguese territory;
Source: Novo, et al.,2015

Methodology

- We considered the territory of Europe divided in administrative units that are designated as NUTS3.

- The data used for calibration was for the period from 2006-2015. Meteorological data existed for the entire period with great detail but historical fire data did not exist for all NUTS.

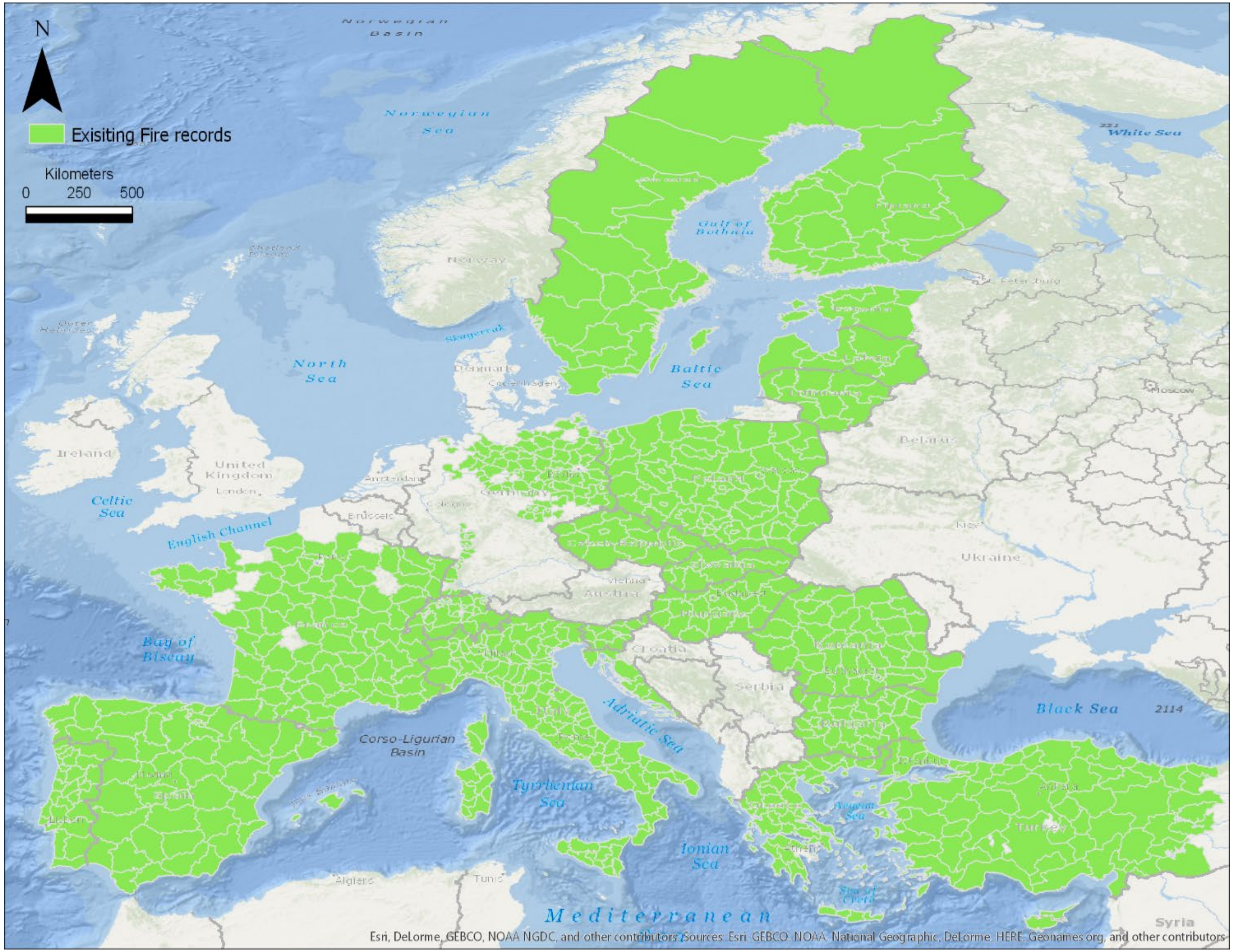


Fig 2. Map depicting the extent of the provided fire records

Methodology Steps

Definition of the Study Area

22 countries were analyzed with their respective NUTS3 between 2006 and 2015.

	Country		Nr. NUTS	From	To	Years
1	Bulgary	BG	29	2006	2015	9
2	Switzerland	CH	24	2006	2014	8
3	Cyprus	CY	1	2006	2015	9
4	Czech Republic	CZ	14	2006	2008	2
5	Germany	DE	106	2006	2015	9
6	Estonia	EE	5	2006	2015	9
7	Greece	EL	50	2006	2011	5
8	Spain	ES	56	2006	2014	8
9	Filand	FI	18	2006	2015	9
10	France	FR	84	2006	2015	9
11	Croatia	HR	21	2006	2015	9
12	Hungary	HU	21	2006	2015	9
13	Italy	IT	111	2006	2015	9
14	Lithuania	LT	10	2006	2015	9
15	Latvia	LV	6	2006	2015	9
16	Poland	PL	66	2006	2015	9
17	Portugal	PT	28	2006	2015	9
18	Romania	RO	43	2006	2015	9
19	Sweden	SE	22	2006	2015	9
20	Slovenia	SI	12	2006	2015	9
21	Slovakia	SK	9	2006	2012	6
22	Turkey	TR	78	2006	2013	7

Tab.3: Countries analyzed with the respective time period

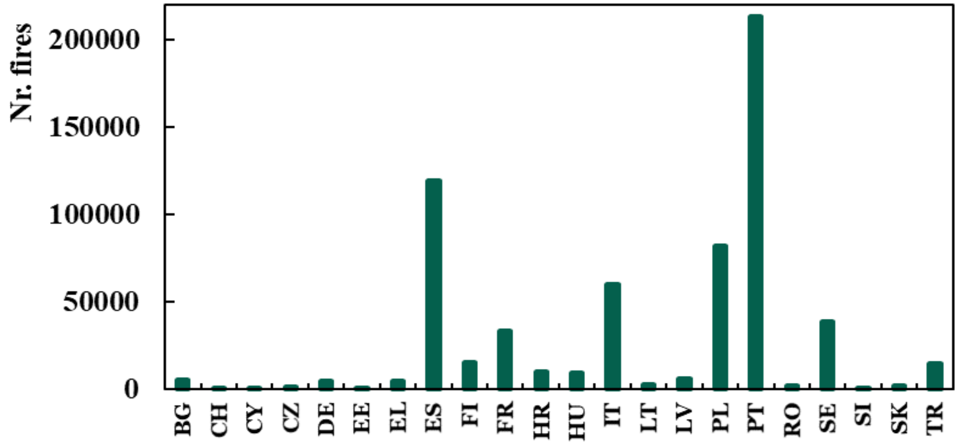


Fig. 7: Number of fires per country (2006-2015)

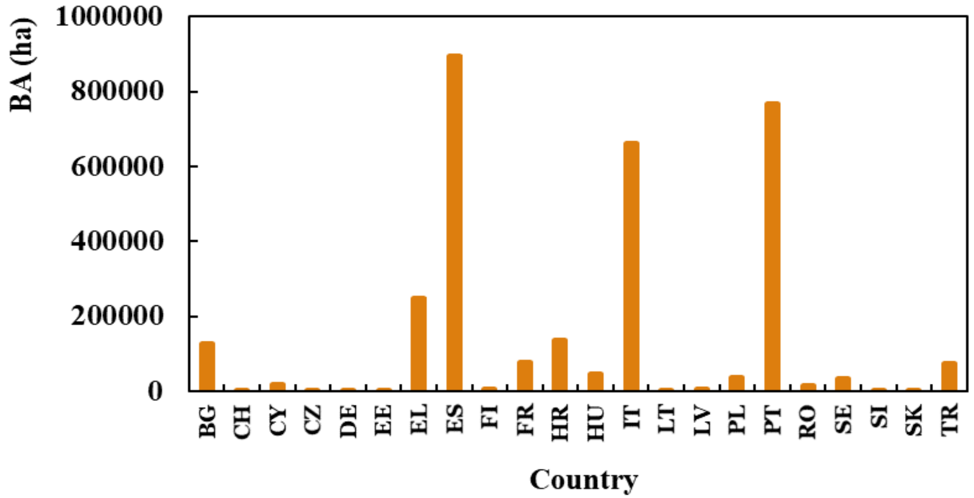
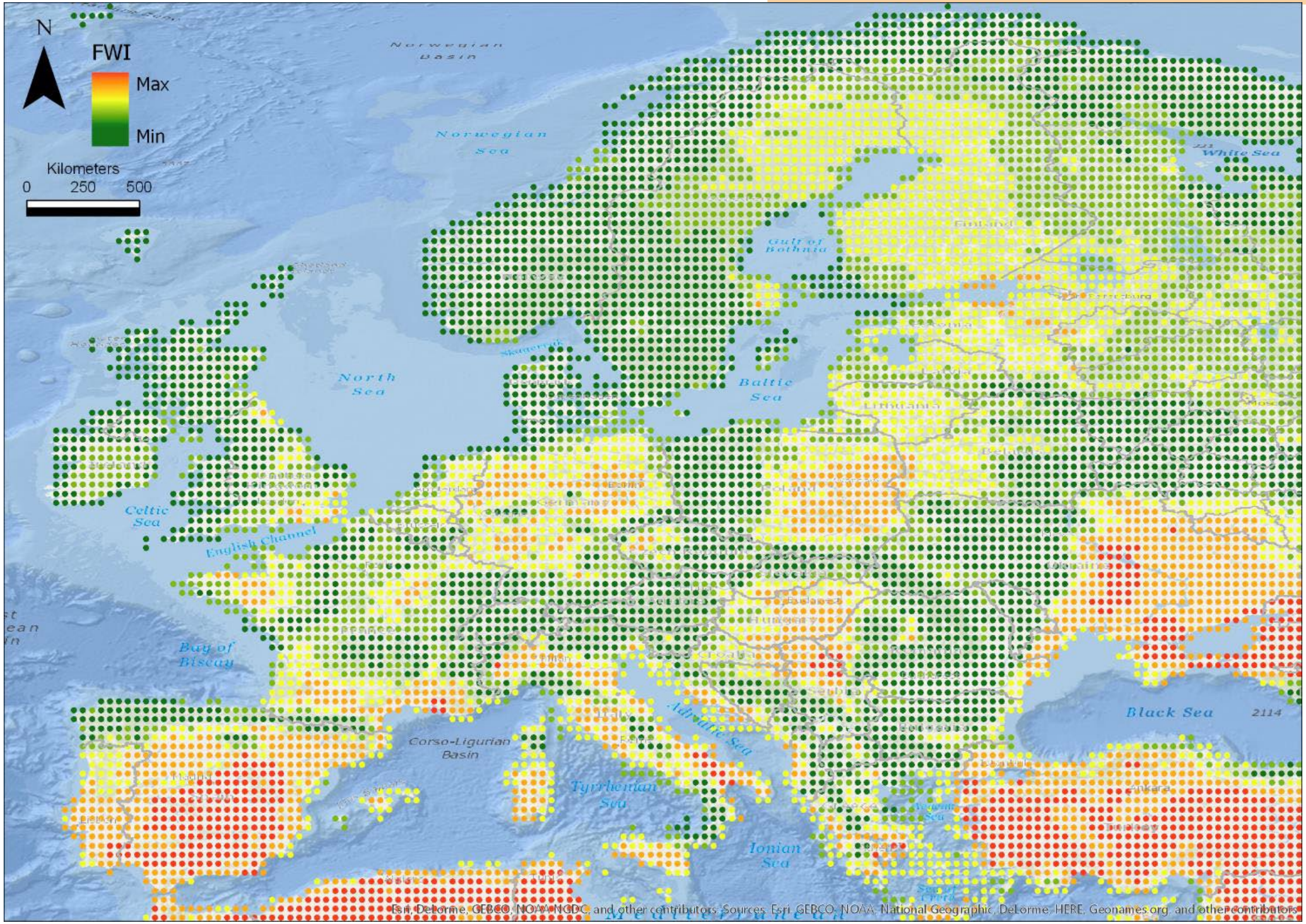


Fig. 8: Burnt area (ha) per country (2006-2015)


N
FWI
Max
Min
Kilometers
0 250 500
Norwegian Basin
Norwegian Sea
White Sea
Gulf of Bothnia
North Sea
Baltic Sea
Celtic Sea
English Channel
Bay of Biscay
Corso-Ligurian Basin
Tyrrhenian Sea
Adriatic Sea
Ionian Sea
Black Sea
2114
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors, Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

Two Fire Seasons

- Calibration process for two different seasons:
  - **Summer season**: May 15th to September 30th; 5 fire danger classes
  - **Winter season**: October 1st to May 14th. 3 fire danger classes

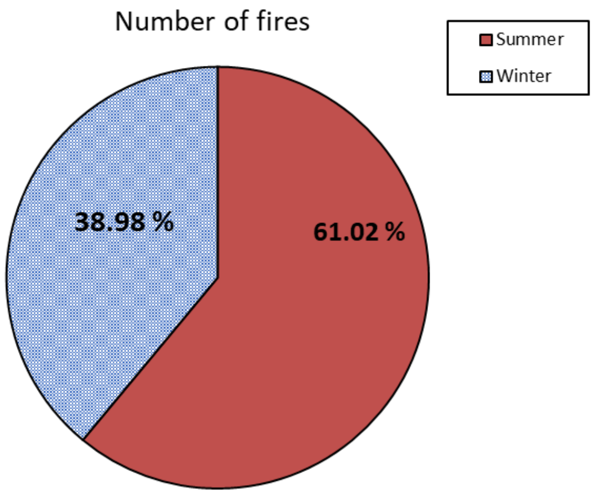


Fig 3. Total number of fires (%)

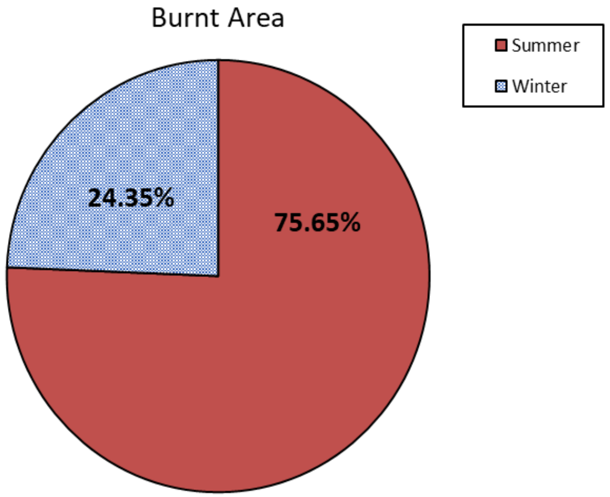
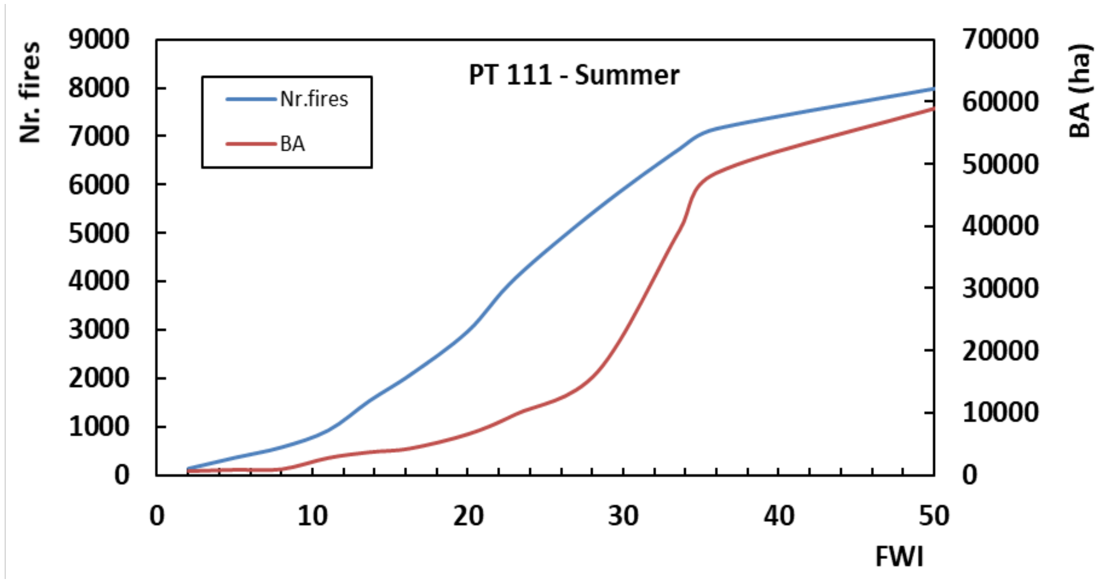
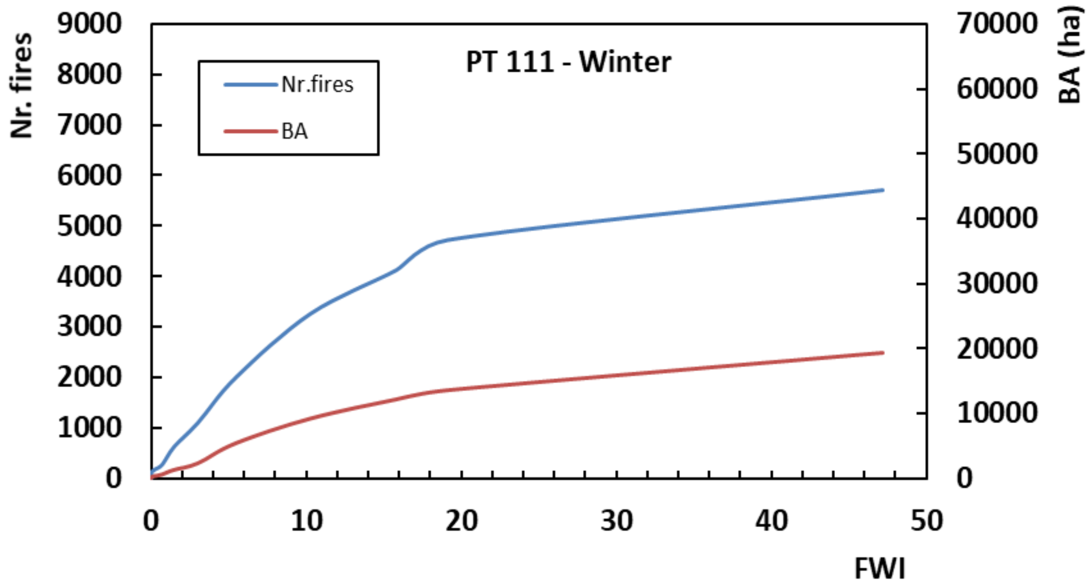


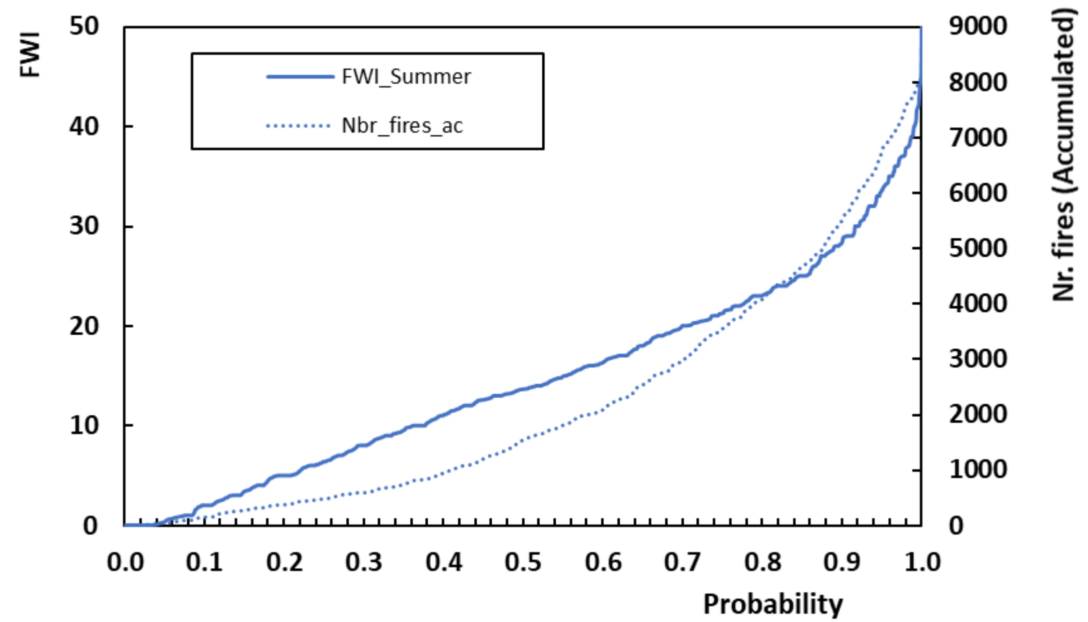
Fig 4. Total burned area (%)

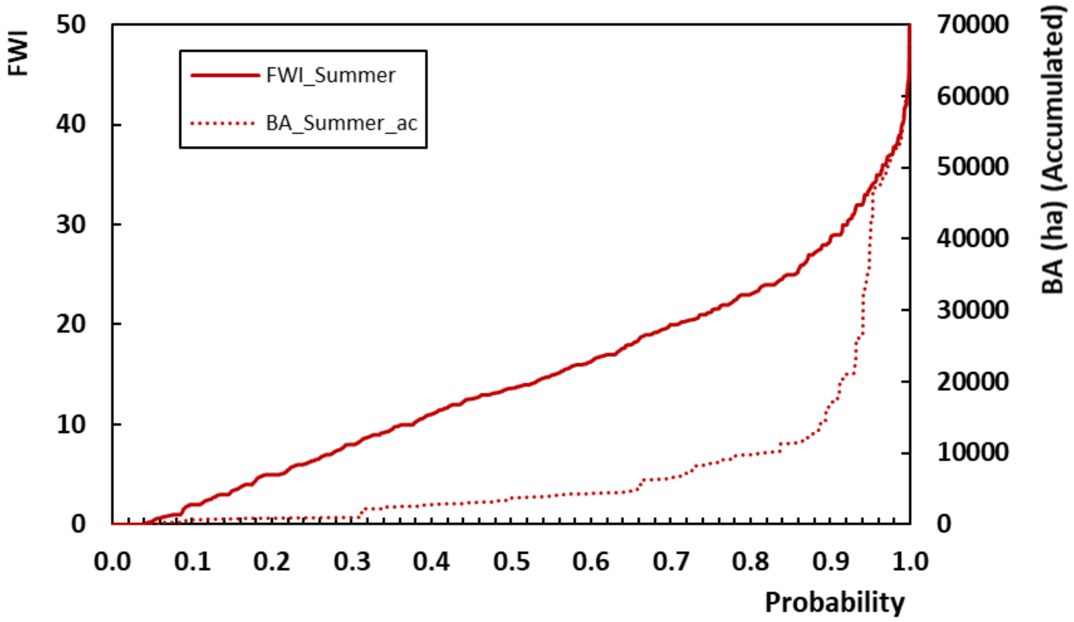
- For each Region and Season we calculated the daily values of FWI, NF and BA, and obtained distributions like these for PT111:





- We can then set a probability of occurrence of values of FWI and the corresponding values of NF and BA:





- We can tabulate these values for each set of parameters:

Probability class	Maximum FWI (limit of the class)	Mean Values		
		FWI	Nr. of fires	BA
0.10	2.0	0.6	1.2	5.3
0.20	5.0	3.4	1.8	1.8
0.30	8.0	6.4	1.7	0.8
0.40	11.0	9.5	2.8	14.6
0.50	13.7	12.5	4.9	7.4
0.60	16.3	14.9	4.4	5.0
0.70	20.0	18.1	7.2	18.4
0.80	23.1	21.4	8.9	25.5
0.90	28.4	25.4	11.6	55.4
0.95	33.6	30.8	20.0	366.9
0.97	36.1	34.9	17.3	381.8
1.00	51.2	39.4	23.7	295.0

Example of results for PT111 (Summer)

- Using these probabilities we can establish the limits that define each class of danger:

Risk Level	a. Summer		b. Winter	
	Risk class	Historical probability	Risk class	Historical probability
1	Very Low	$P < 0.30$	Low	$P < 0.50$
2	Low	$0.30 \leq P < 0.60$	Moderate	$0.50 \leq P < 0.90$
3	Moderate	$0.60 \leq P < 0.90$	High	$P \geq 0.90$
4	High	$0.90 \leq P < 0.97$	–	–
5	Very High	$P \geq 0.97$	–	–

3. Results - Calibration of the Canadian System (Calibration tables)

- The entire process, cycled through all the NUTS3 regions in the defined study area, resulted in two calibration tables, one for Summer and other for Winter.

Calibration table for Summer (22 from 769 NUTS3)

	Country	NUTS_ID	Break_P_30	Break_P_60	Break_P_90	Break_P_97
1	BG	BG312	7.8	22	39.5	51
2	CH	CH023	0.9	5.6	13.9	19.6
3	CY	CY000	25.5	32	44.1	50.5
4	CZ	CZ041	2.8	9.6	20.6	27.6
5	DE	DE122	4.7	13	24.7	30.7
6	EE	EE001	1	4.3	11	19
7	EL	EL111	19.8	33.8	51.4	58.2
8	ES	ES411	28	39.2	52.8	62.5
9	FI	FI195	0.7	4.2	13.7	25
10	FR	FR213	6	15	29	38.7
11	HR	HR035	15.7	29.4	47.5	56
12	HU	HU222	8.4	19.1	35.3	45.6
13	IT	ITC34	0.6	6.4	17.4	22.9
14	LT	LT001	2.5	8.8	20.7	29.5
15	LV	LV003	2.1	7.4	19.4	29.4
16	PL	PL114	5.7	15	28	40.3
17	PT	PT114	6	13.8	24.1	32.5
18	RO	RO116	5.9	17	31.7	38.8
19	SE	SE122	1.6	8	21	29.2
20	SI	SI012	5	14.9	29	40
21	SK	SK022	6.1	16.3	29	37.5
22	TR	TR411	28.4	45.1	60.8	68.6

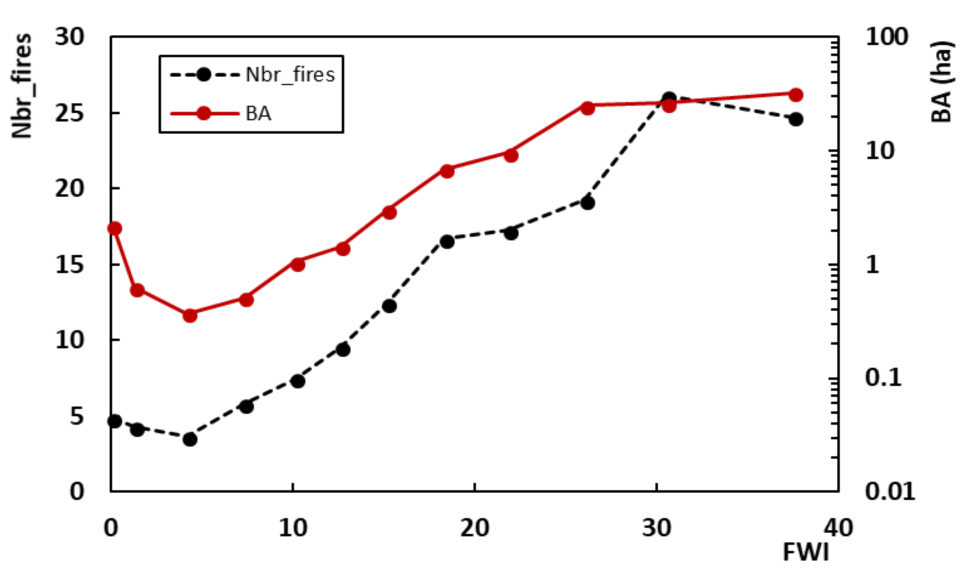
Calibration table for Winter (22 from 769 NUTS3)

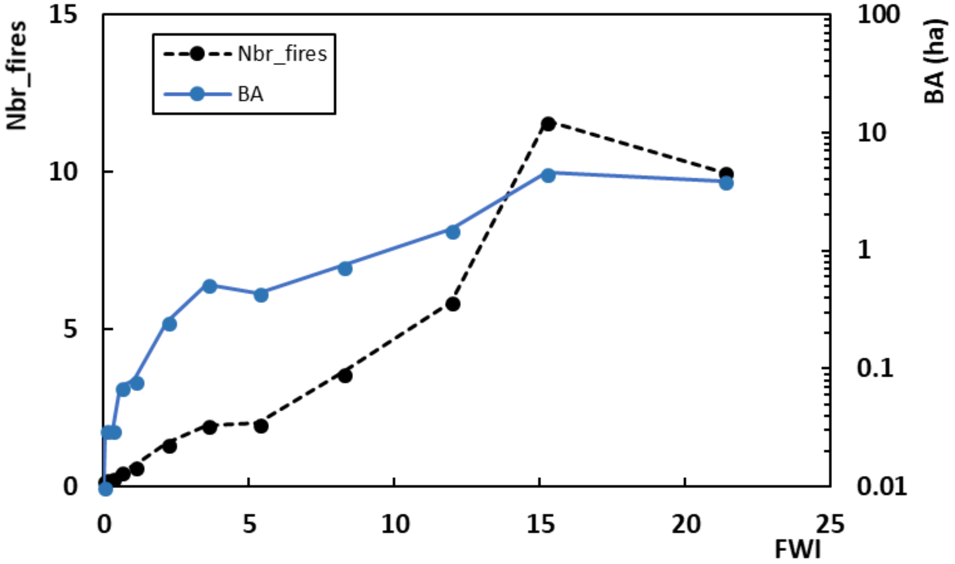
	Country	NUTS_ID	Break_P_50	Break_P_90
1	BG	BG312	1	16.3
2	CH	CH023	0.4	6
3	CY	CY000	12.4	30.2
4	CZ	CZ041	0.4	8.6
5	DE	DE122	0.7	9.1
6	EE	EE001	0.5	4.3
7	EL	EL111	2.2	15.2
8	ES	ES411	5.9	23.3
9	FI	FI195	0.2	1
10	FR	FR213	0.8	12
11	HR	HR035	3.3	18
12	HU	HU222	2.3	18.3
13	IT	ITC34	0.3	4.2
14	LT	LT001	0.3	8
15	LV	LV003	0.4	5.1
16	PL	PL114	0.8	12.6
17	PT	PT114	1.6	10.1
18	RO	RO116	0.9	15.9
19	SE	SE122	0.4	7
20	SI	SI012	1	13.3
21	SK	SK022	0.7	13.1
22	TR	TR411	4.6	23.5

Validation

- In order to assess the existence of the well behaved functions f1 and f2 we calculated the corrrelation coefficient bwteen the pairs of variables testing a linear relationship for both.

- We did this for both functions but explored more extensively the case of f1.





R	$\overline{Nbr\_fires}_{SUP}$	$\overline{BA}_{SUP}$
Summer – PT114	0.97	0.91
Winter – PT114	0.95	0.92

- We considered the existence of three classes of values of R:

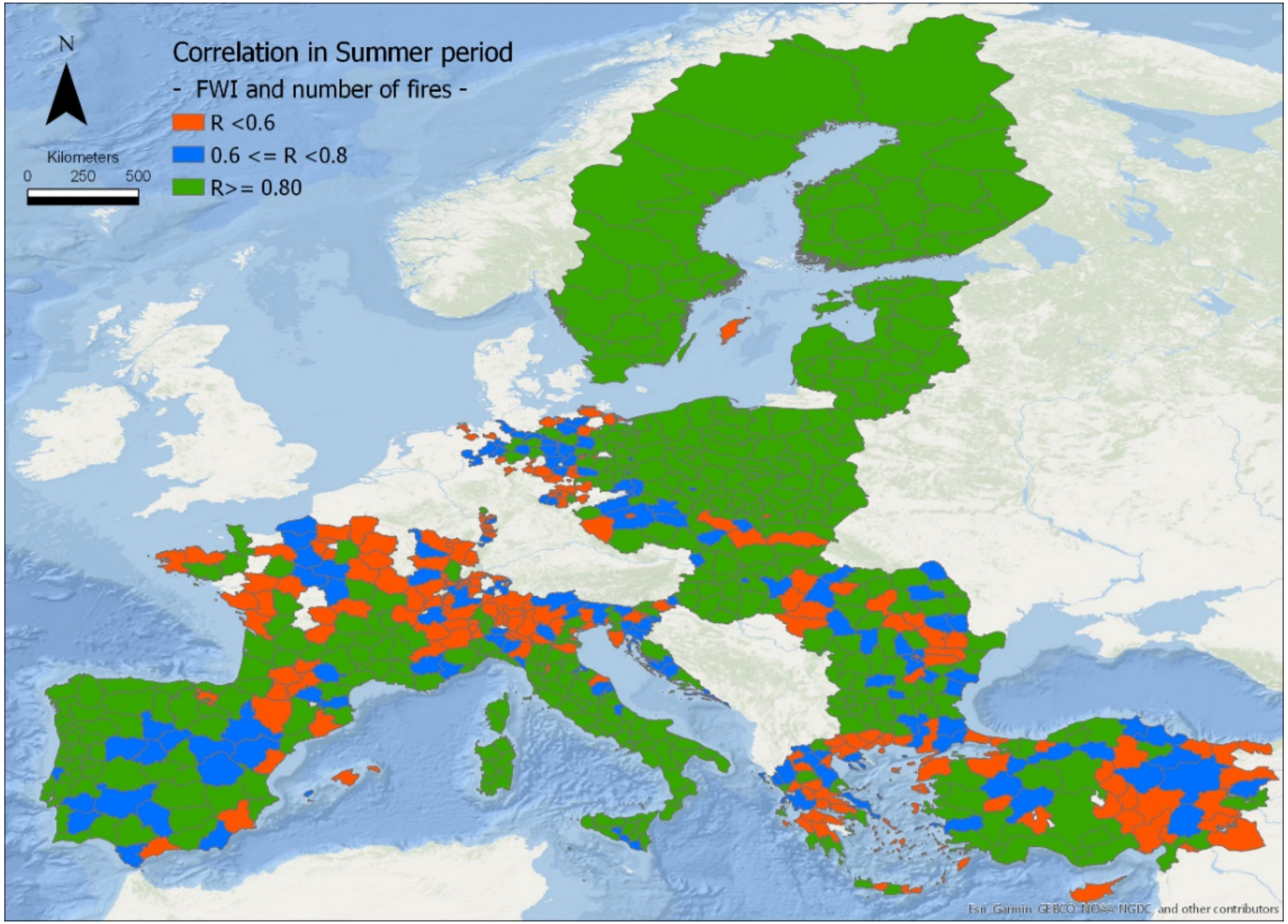
(A) $\boldsymbol{R} \geq 0.8$ that were considered high correlation values;

(B) $0.8 > \boldsymbol{R} \geq 0.6$ that were considered average correlation values;

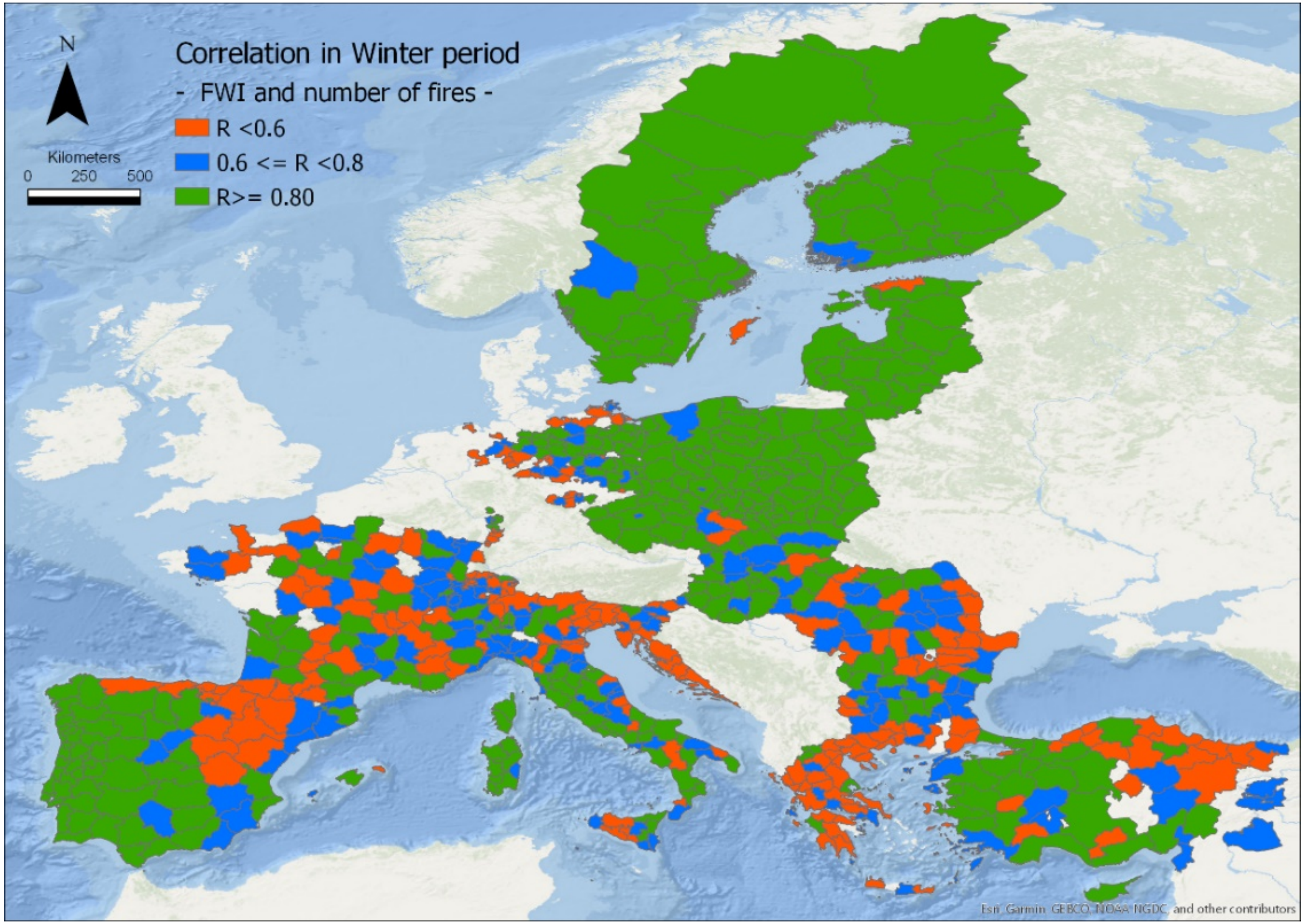
(C) $0.6 > \boldsymbol{R} > 0$ that were considered low correlation values.

Class	Summer		Winter	
A	414	55.4 %	354	48.0 %
B	139	18.6 %	170	23.0 %
C	194	26.0%	214	29.0 %
Total	747	100 %	738	100 %

Summer period



- Winter period



- Class A Units $R \geq 0.8$

  - We selected the 15 cases with highest values of burned area and identified them as cases that deserve more attention because they correspond to “bad fire days”.
  - Summer: cases which the maximum value of the daily burned are exceeded 10000ha;
  - Winter: cases which the maximum value of the daily burned are exceeded 1000ha.

- Summer

Ref.	NUTS	Day	Risk Level	$FWI_{d,S,U}$	$BA_{d,S,U}$ ha	R	$BA_{T,S,U}$ ha	$BA_{Y,S,U}$ ha/year	$Med(BA_{Y,S,U})$ ha/year	$Y_{T,U}$
1	SE125	31/07/2014	2	2	12807.0	0.96	13041.7	1304.2	14.4	10
2	TR611	31/07/2008	3	5	15822.2	0.95	21573.9	2696.7	555.9	8
3	ES413	19/08/2012	3	3	11664.7	0.85	39479.3	4386.6	2231.2	9
4	PT168	30/08/2009	3	9	9508.1	0.94	58392.2	5839.2	4457.9	10
5	ES512	22/07/2012	3	3	8770.3	0.89	11141.3	1237.9	41.5	9
6	BG341	26/08/2012	3	4	8147.6	0.91	15836.9	1583.7	481.8	10
7	ES523	28/06/2012	4	2	28880.1	0.95	51294.3	5699.4	307.1	9
8	EL254	23/08/2007	4	1	20700.0	0.93	20982.2	3497.0	31.8	6
9	PT118	09/07/2013	4	13	13729.6	0.90	84668.1	8466.8	6306.2	10
10	ITG25	23/07/2009	4	5	13488.0	0.98	21777.3	3111.0	1204.5	7
11	EL300	21/08/2009	4	2	9390.7	0.86	15740.1	2623.4	747.9	6
12	EL255	23/08/2007	4	2	9033.8	0.91	16607.8	2768.0	164.1	6
13	ITG26	23/07/2007	4	10	8066.8	0.91	20417.6	2916.8	2804.8	7
14	PT150	18/07/2012	5	5	21437.3	0.91	25932.1	2593.2	261.8	10
15	ES114	06/08/2006	5	64	10520.3	0.94	47724.7	5302.7	356.7	9

- Winter

Ref.	NUTS	Day	Risk Level	$FWI_{d,S,U}$	$BA_{d,S,U}$ ha	R	$BA_{T,S,U}$ ha	$BA_{Y,S,U}$ ha/year	$Med(BA_{Y,S,U})$ ha/year	$Y_{T,U}$
1	ES523	10/03/2006	1	2	2094.7	0.95	5103.0	567.0	184.6	9
2	ES521	24/01/2009	1	3	961.9	0.82	1916.0	212.9	100.5	9
3	ES419	28/02/2012	2	12	2522.0	0.82	24093.0	275.2	1594.1	9
4	PT161	02/04/2015	2	8	1575.3	0.95	2476.7	247.7	84.3	10
5	EL134	17/11/2011	2	1	1315.0	0.87	1646.8	274.5	18.4	6
6	ES413	11/03/2012	2	12	1131.1	0.95	33513.1	3723.7	2752.9	9
7	ES617	04/02/2012	2	1	797.7	0.92	1603.6	178.2	36.5	9
8	ES113	13/10/2011	3	46	6110.6	0.93	51835.6	5759.5	3757.7	9
9	PT118	03/10/2011	3	32	2161.0	0.97	33117.4	3311.7	1863.2	10
10	PT112	27/03/2012	3	15	1824.9	0.99	8109.7	811.0	464.9	10
11	FR813	02/10/2009	3	2	1190.4	0.83	2959.4	295.9	174.0	10
12	HU331	29/04/2012	3	4	1058.9	0.93	1957.5	195.8	66.2	10
13	PT164	28/03/2012	3	7	983.7	0.97	3571.6	357.2	66.9	10
14	ES111	31/03/2012	3	24	879.6	0.97	5760.2	640.0	479.7	9
15	PT165	29/03/2012	3	16	838.3	0.95	10777.5	1077.8	1029.4	10

- Class C Units $R<0.6$
  - We selected the following cases:
  - Summer: days with burned areas larger than 1000ha.
  - Winter: days with burned areas larger than 500ha.

- Summer

Ref.	NUTS	Day	Risk Level	$FWI_{d,S,U}$ (Daily)	$BA_{d,S,U}$ (Daily)	R	$BA_{T,S,U}$ (Total)	$BA_{Y,S,U}$	$Med(BA_{Y,S,U})$	Y_T
					ha		ha	ha/year	ha/year	
1	EL233	24/08/2007	4	6	46368.6	-0.01	72248.5	12041.4	175.5	6
2	EL421	22/07/2008	2	1	13239.8	-0.19	13316.2	2219.4	2.1	6
3	ES522	29/06/2012	5	1	10613.3	0.45	18133.3	2014.8	97.9	9
4	ES617	30/08/2012	3	1	8037.1	0.31	12277.0	1364.1	416.9	9
5	EL122	25/07/2007	5	1	2916.6	0.53	3681.4	736.3	60.0	5
6	EL413	25/07/2007	3	1	2570.8	-0.24	2863.0	477.2	50.7	6
7	ES532	26/07/2013	5	2	2347.2	0.49	4020.3	446.7	25.3	9
8	CY000	12/08/2012	2	3	1891.5	0.43	17203.8	1720.4	1456.5	1[illegible]
9	EL125	24/07/2007	4	1	1709.1	0.01	1726.8	575.6	14.5	3
10	EL253	17/07/2007	3	1	1542.8	0.49	2334.8	467.0	24.9	5
11	EL132	25/07/2007	5	1	1534.2	0.46	3671.8	734.4	12.9	5
12	ES241	12/08/2006	2	1	1435.6	-0.67	2015.4	223.9	37.7	9
13	ES620	01/07/2012	3	1	1342.2	0.51	3230.7	359.0	136.4	9
14	TR222	30/07/2008	4	2	1304.0	0.54	1909.0	477.3	38.9	4
15	EL244	24/08/2007	3	1	1222.3	0.38	1643.6	273.9	63.4	6

- Winter

Ref.	NUTS	Day	Risk Level	$FWI_{d,S,U}$ (Daily)	$BA_{d,S,U}$ (Daily)	R	$BA_{T,S,U}$ (Total)	$BA_{Y,S,U}$	$Med(BA_{Y,S,U})$	Y_T
					ha		ha	ha/year	ha/year	
1	ES241	08/03/2012	3	3	2734.1	0.13	3409.0	378.8	65.3	9
2	ES120	23/10/2011	3	55	2374.6	0.58	66682.7	7409.2	6461.7	9
3	ES130	27/03/2012	2	68	2146.5	-0.12	65930.1	7325.6	7652.6	9
4	HR034	19/02/2011	2	1	1318.0	0.04	7246.5	724.7	551.6	1[illegible]
5	EL434	20/04/2008	3	4	906.5	0.36	999.6	199.9	15.0	5
6	TR811	18/04/2012	2	5	840.1	0.50	955.2	119.4	17.0	8
7	HU311	07/04/2009	2	4	836.0	0.44	13846.2	1384.6	974.4	1[illegible]
8	ES243	17/03/2010	2	7	805.7	0.23	1887.3	209.7	116.3	9
9	HR035	19/02/2008	2	1	800.0	0.18	4717.0	471.7	332.6	1[illegible]
10	HR033	26/03/2012	3	1	632.9	-0.59	4409.8	630.0	349.4	7
11	HR032	27/03/2012	3	4	549.3	0.53	2069.1	206.9	74.3	1[illegible]
12	ES212	27/02/2010	2	7	511.1	0.49	1087.5	120.8	75.6	9

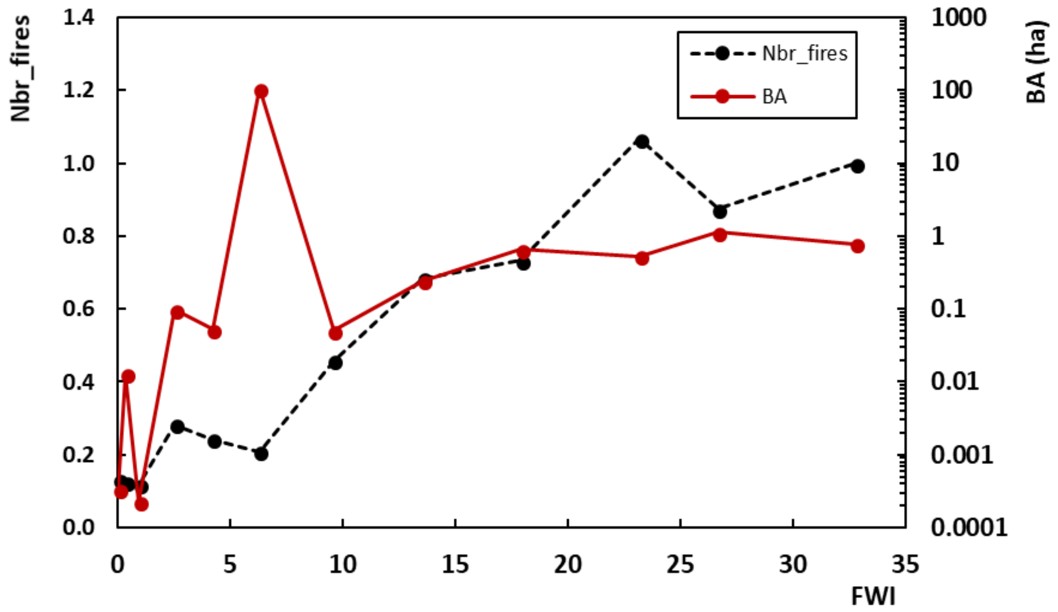
- Analysis of Large Burned Area Days (selected cases)

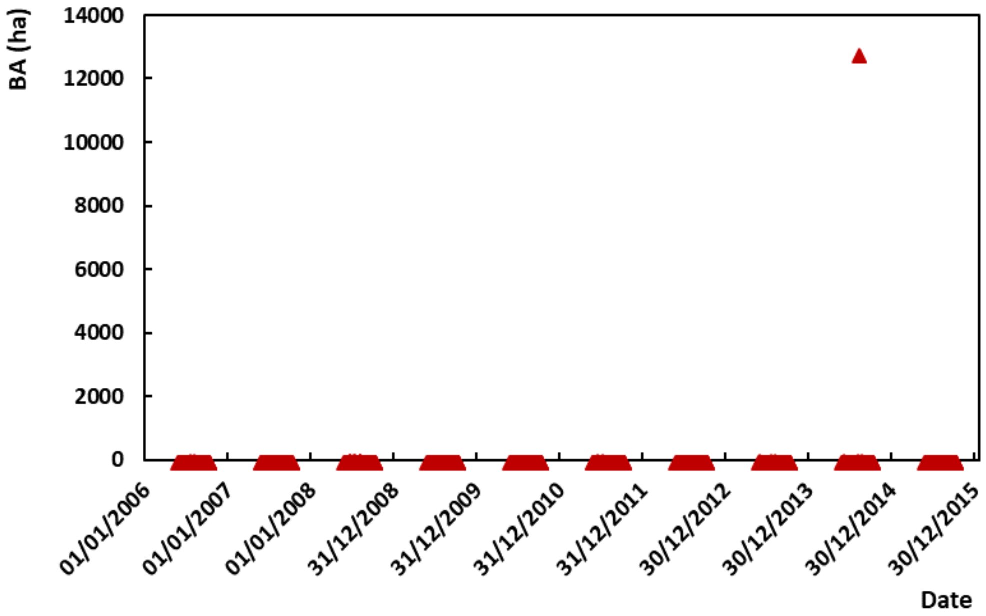
Class	Season	NUTS	Day	Risk Level	$FWI_{d,S,U}$	$BA_{d,S,U}$ ha	R	$BA_{T,S,U}$ ha	$BA_{Y,S,U}$ ha/year	$Med(BA_{Y,S,U})$ ha/year	$Y_{T,U}$
Class A $R \geq 0.8$	Summer	SE125	31/07/2014	2	2	12807.0	0.96	13041.7	1304.2	14.4	10
		TR611	31/07/2008	3	5	15822.2	0.95	21573.9	2696.7	555.9	8
		ES413	19/08/2012	3	3	11664.7	0.85	39479.3	4386.6	2231.2	9
	Winter	ES523	10/03/2006	1	2	2094.7	0.95	5103.0	567.0	184.6	9
		ES521	24/01/2009	1	3	961.9	0.82	1916.0	212.9	100.5	9
		ES419	28/02/2012	2	12	2522.0	0.82	24093.0	275.2	1594.1	9
Class C $R < 0.6$	Summer	EL233	24/08/2007	4	6	46368.6	-0.01	72248.5	12041.4	175.5	6
		EL421	22/07/2008	2	1	13239.8	-0.19	13316.2	2219.4	2.1	6
		ES522	29/06/2012	5	1	10613.3	0.45	18133.3	2014.8	97.9	9
	Winter	ES241	08/03/2012	3	3	2734.1	0.13	3409.0	378.8	65.3	9
		ES120	23/10/2011	3	55	2374.6	0.58	66682.7	7409.2	6461.7	9
		ES130	27/03/2012	2	68	2146.5	-0.12	65930.1	7325.6	7652.6	9

- Class A - Summer

SE125 (31/07/2017):

- Risk level: 2
- BA: 12807.0 ha

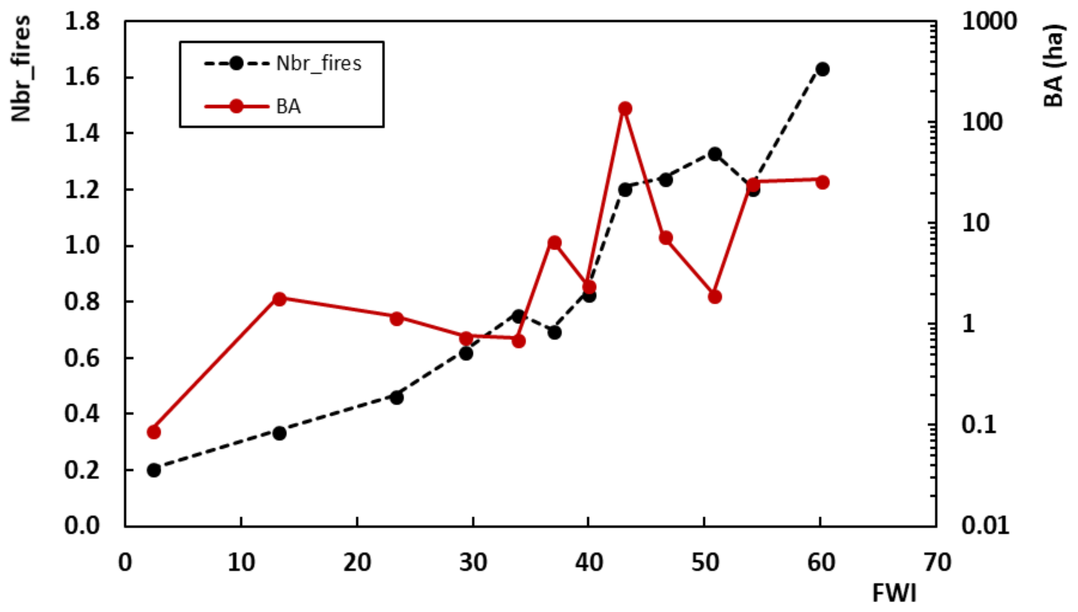


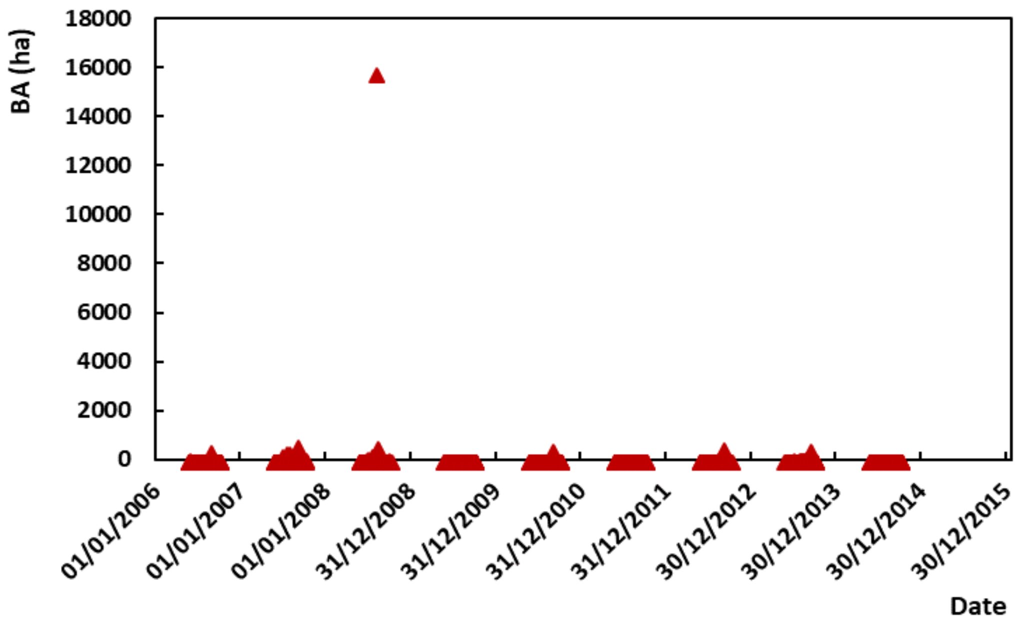


- Class A - Summer

TR611 (31/07/2008):

- Risk level: 3
- BA: 15822.2 ha

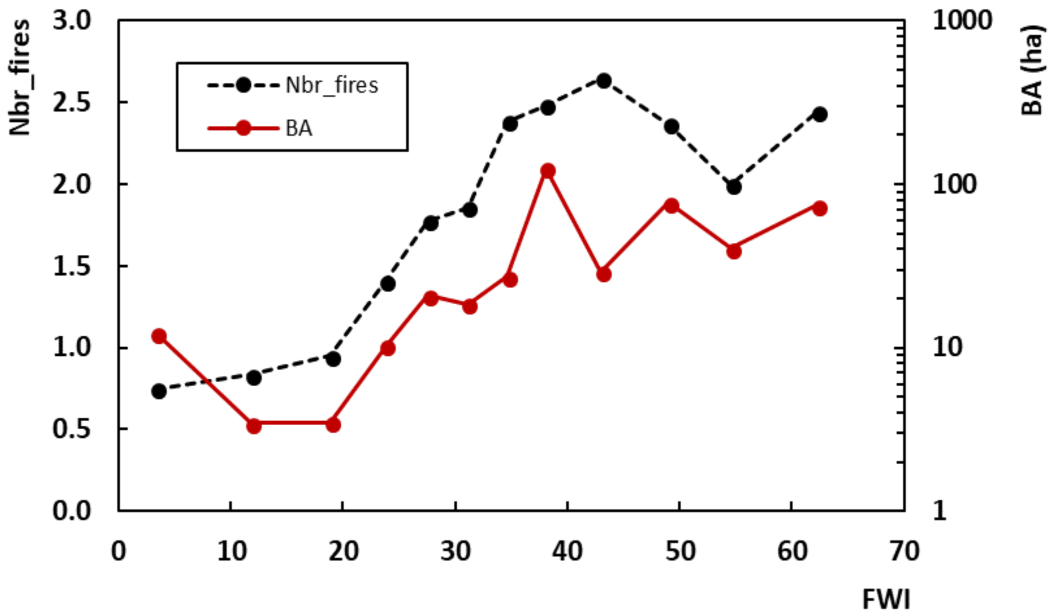


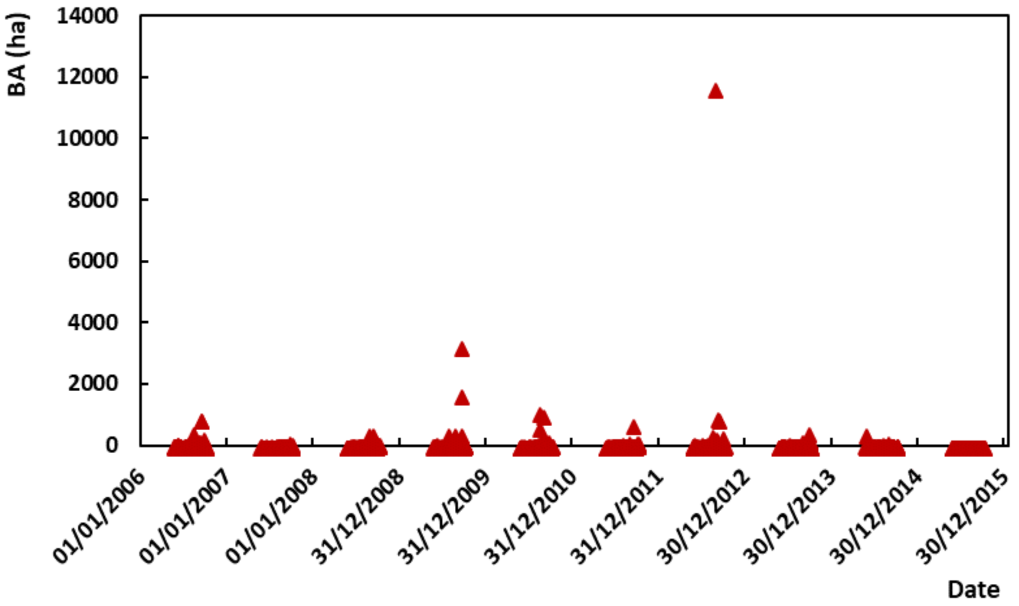


- Class A - Summer

ES413 (19/08/2012):

- Risk level: 3
- BA: 11664.7ha

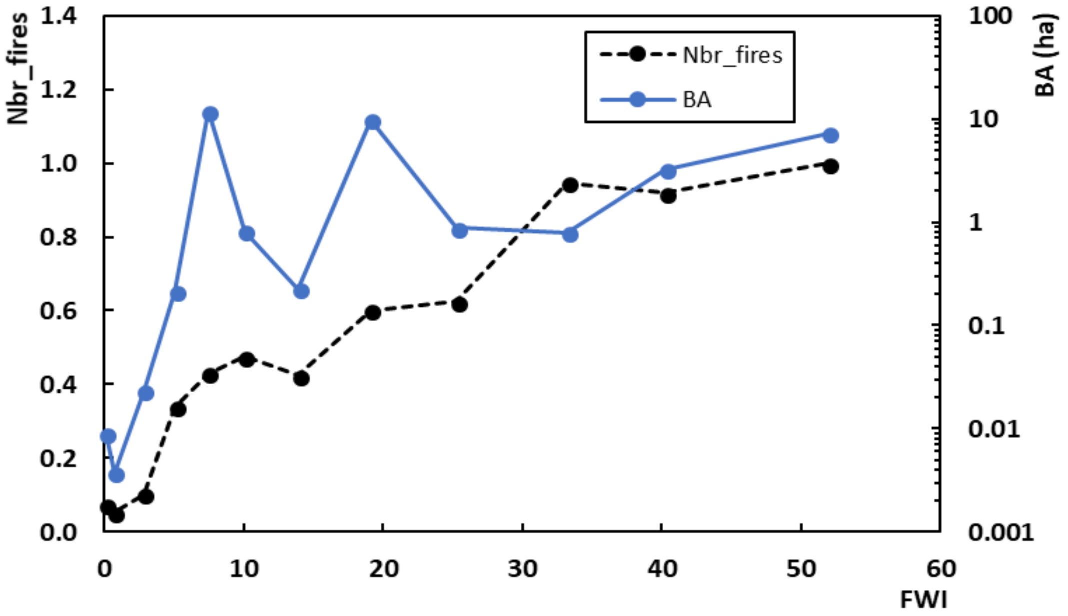


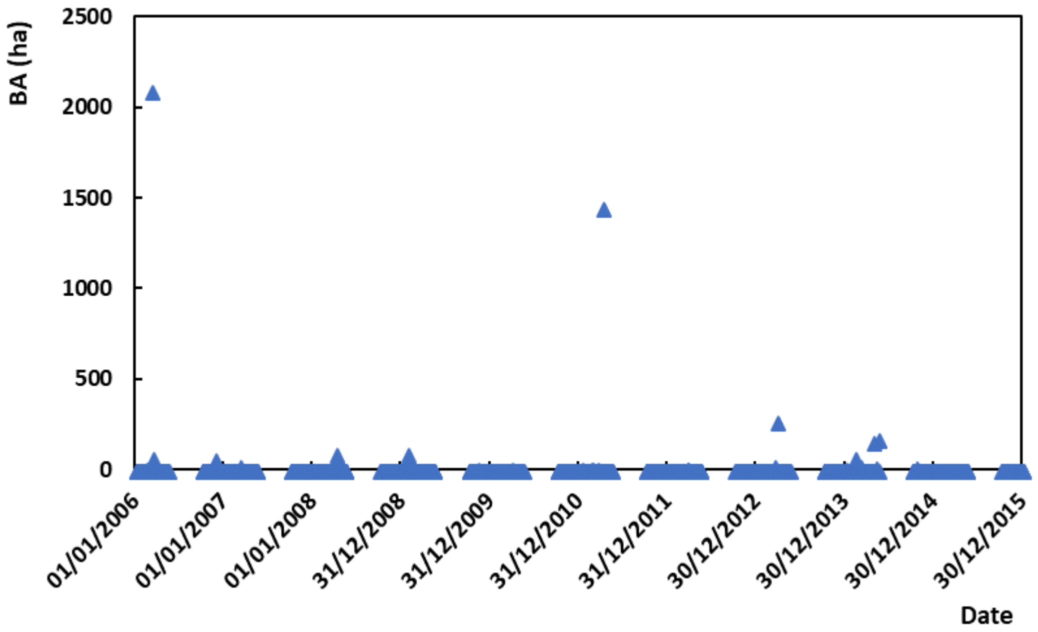


- Class A - Winter

ES523 (10/03/2006):

- Risk level: 1
- BA: 2094.7 ha

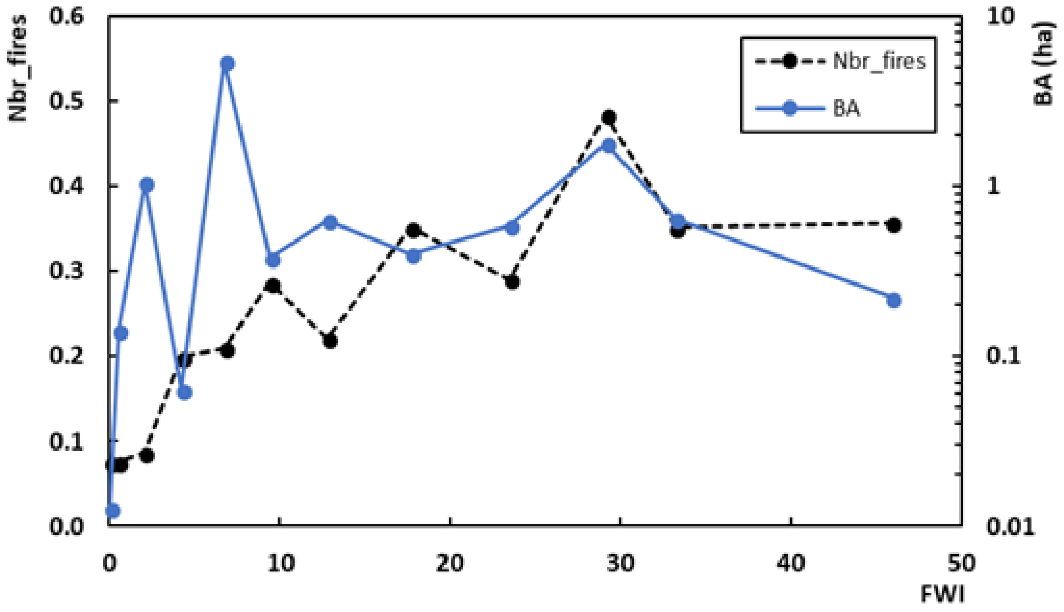


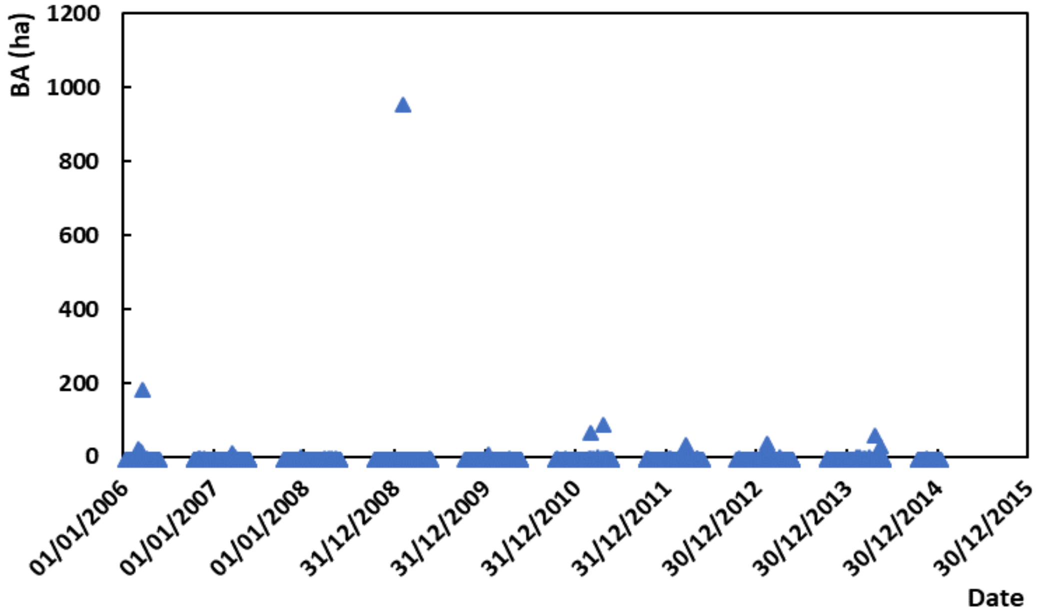


- Class A - Winter

ES521 (24/01/2009):

- Risk level: 1
- BA: 961.9 ha

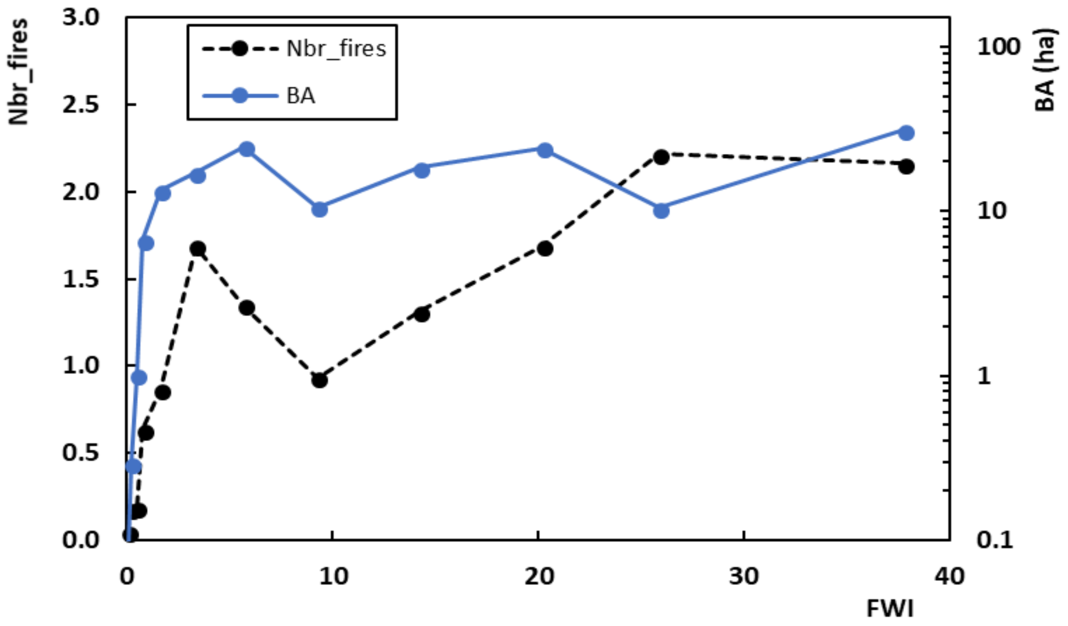


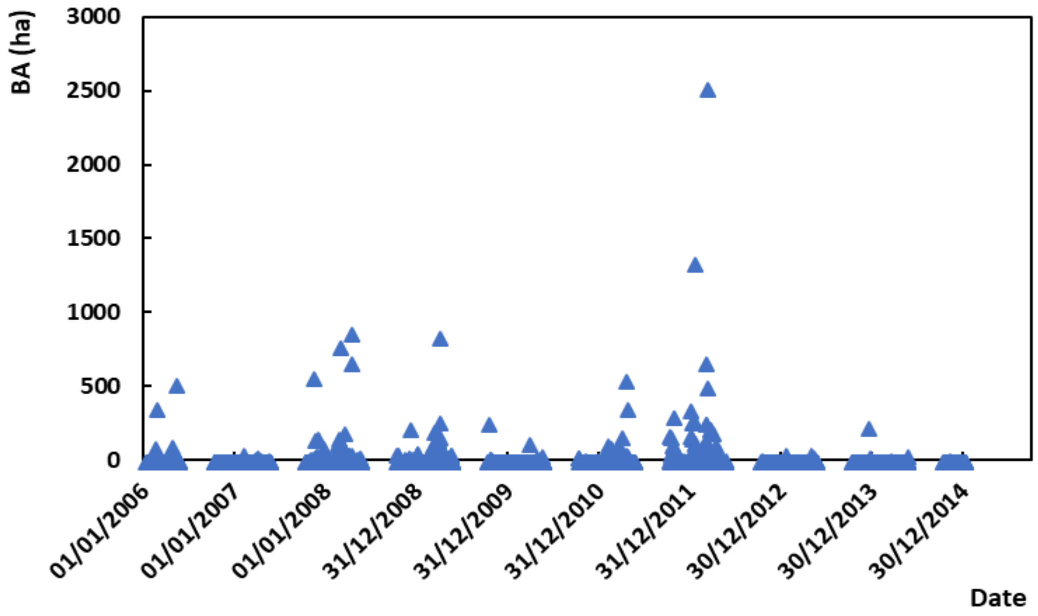


- Class A - Winter

ES419 (28/02/2012):

- Risk level: 2
- BA: 2522.0 ha

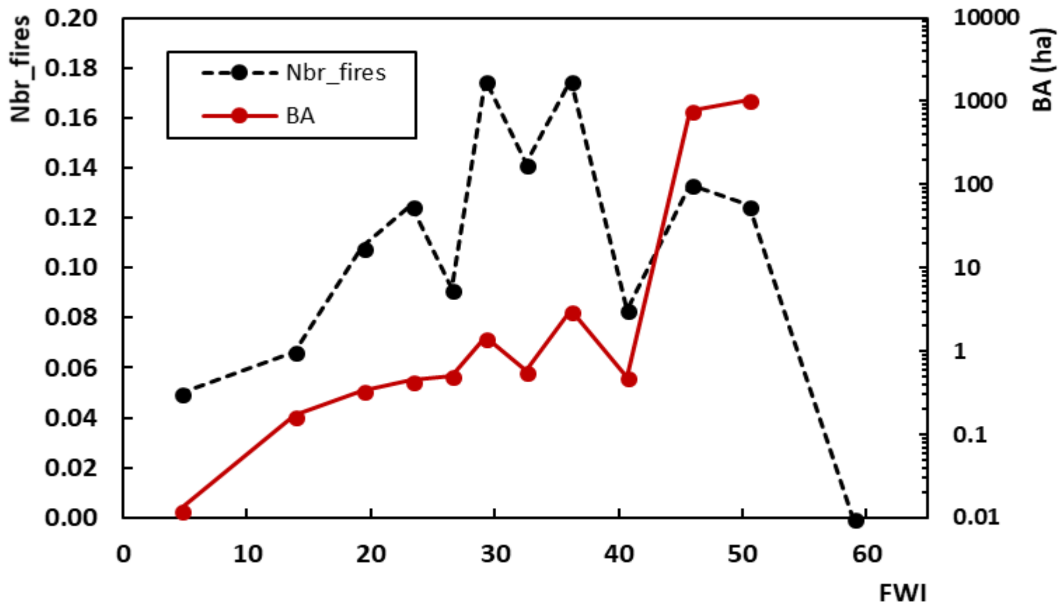


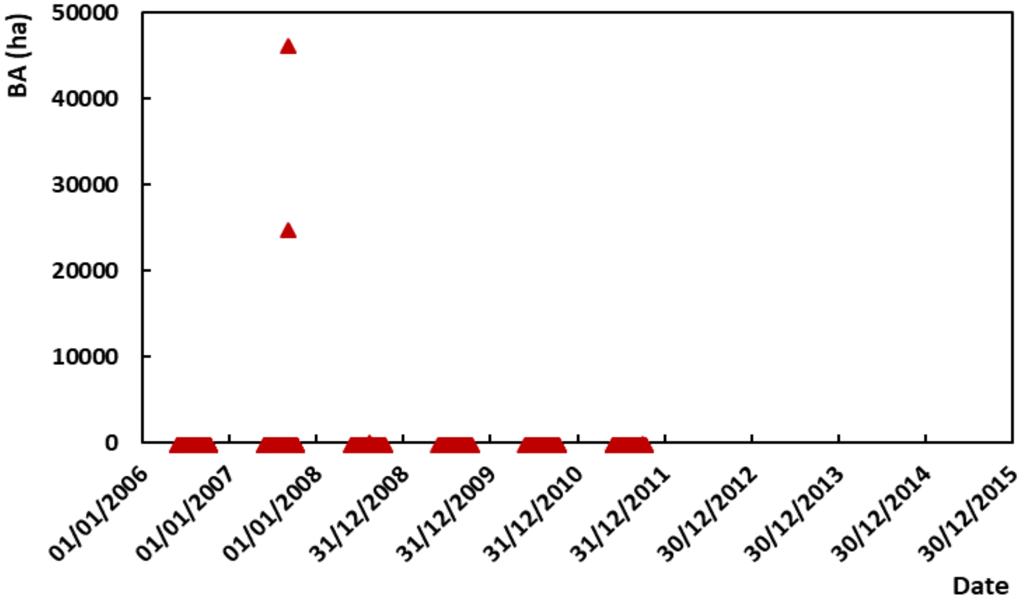


- Class C - Summer

EL233 (24/08/2007):

- Risk level: 4
- BA: 46368.6 ha

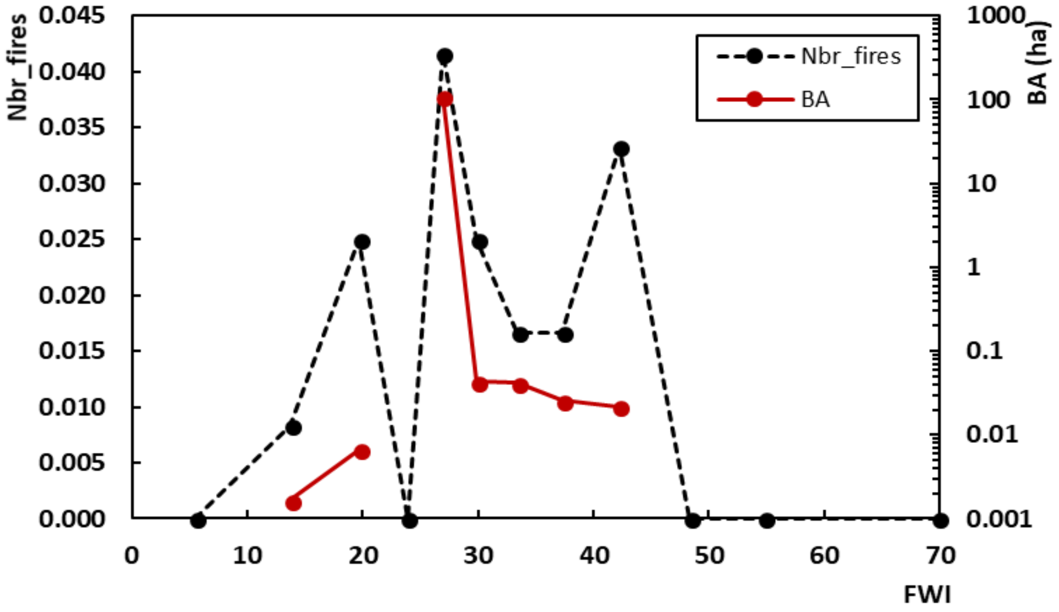


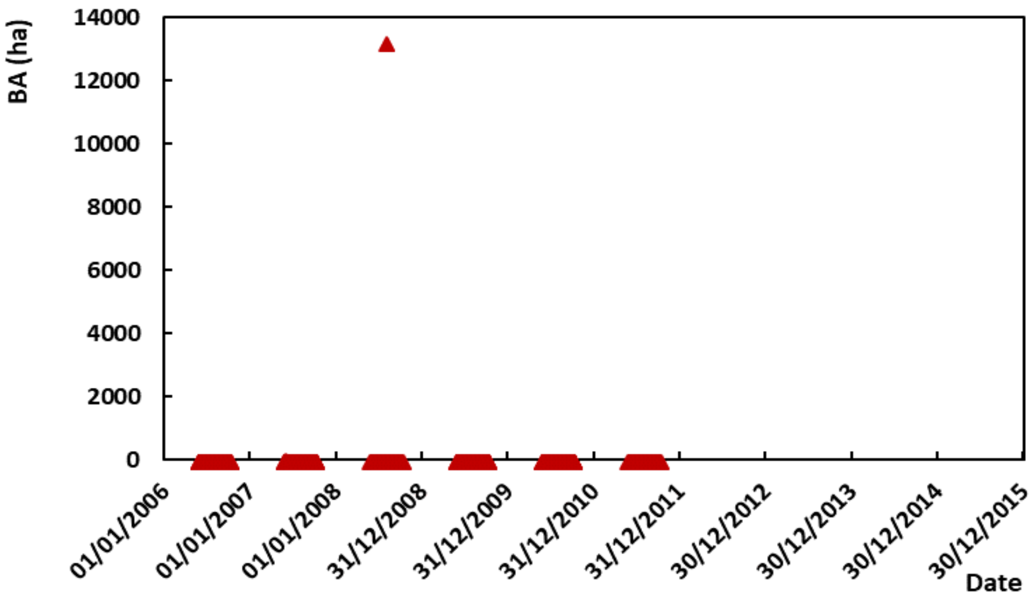


- Class C - Summer

EL421 (22/07/2008):

- Risk level: 2
- BA: 13239.8 ha

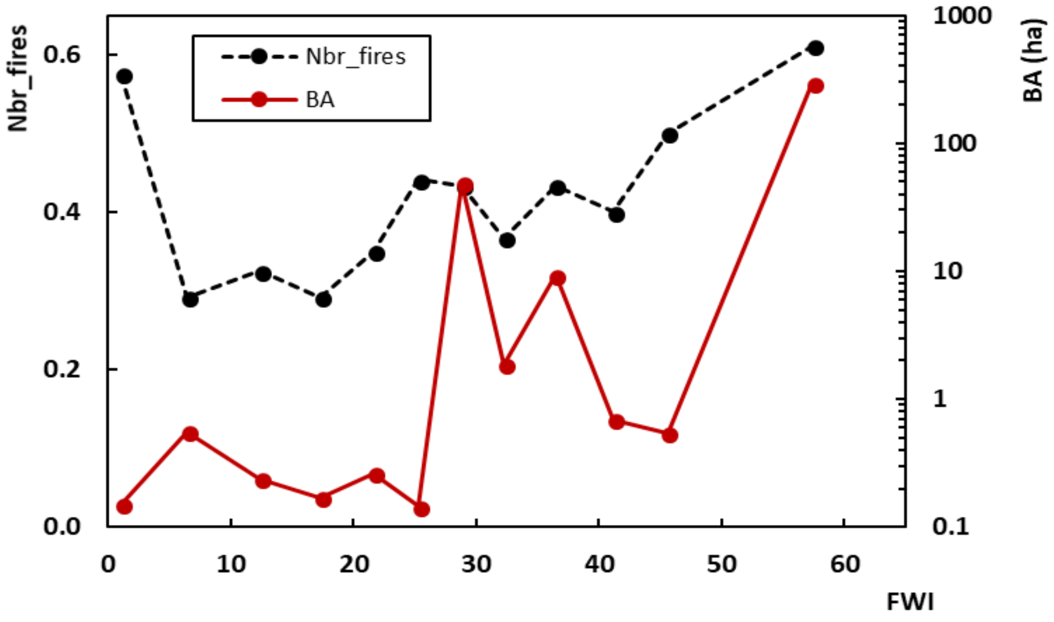


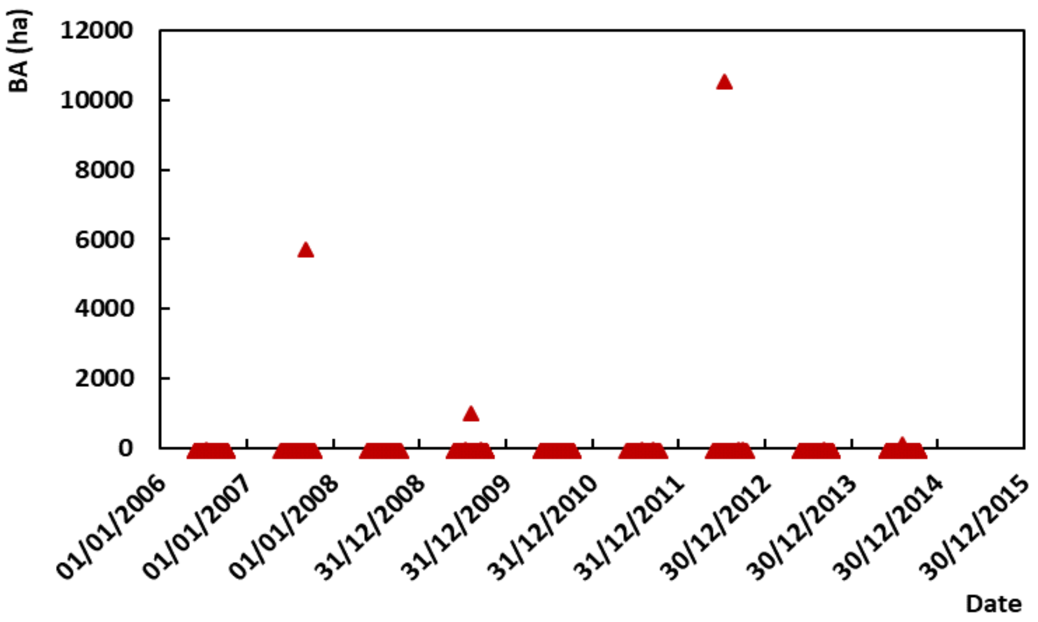


- Class C - Summer

ES522 (29/06/2012):

- Risk level: 5
- BA: 10613.3 ha



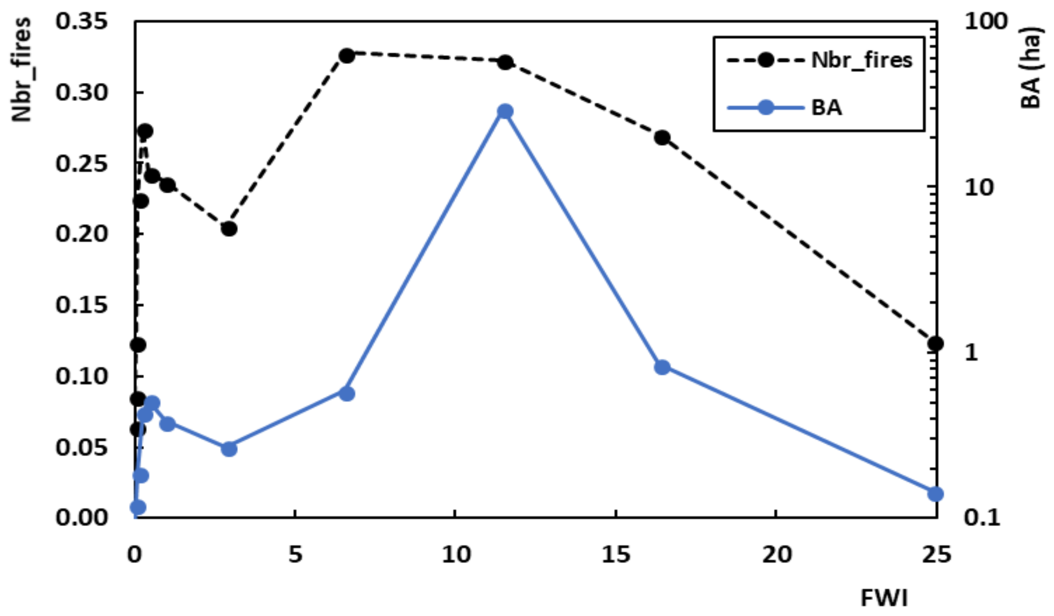


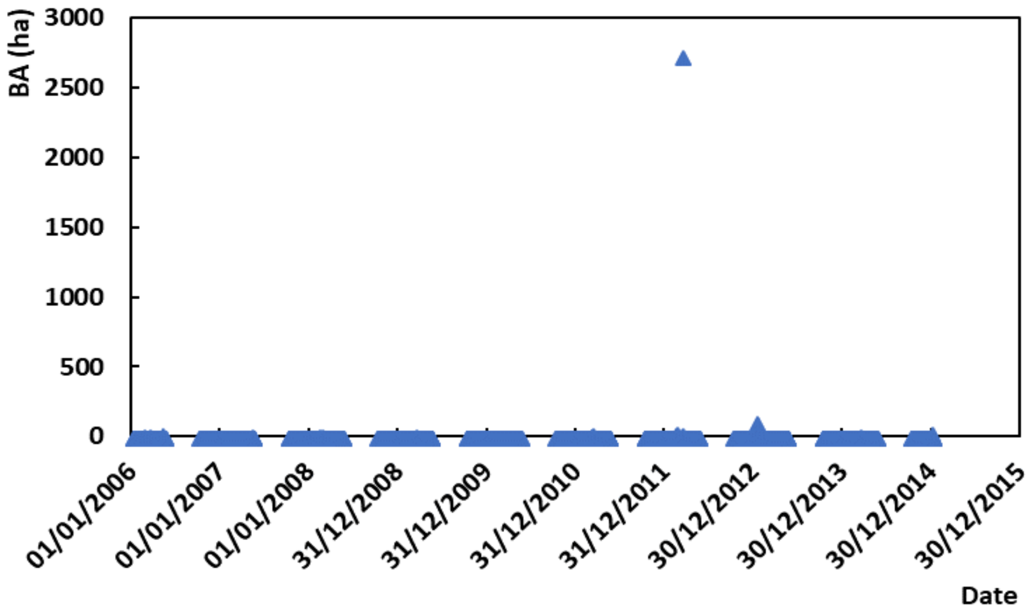
- Class C - Winter

ES241 (08/03/2012):

– Risk level: 3

– BA: 2734.1 ha



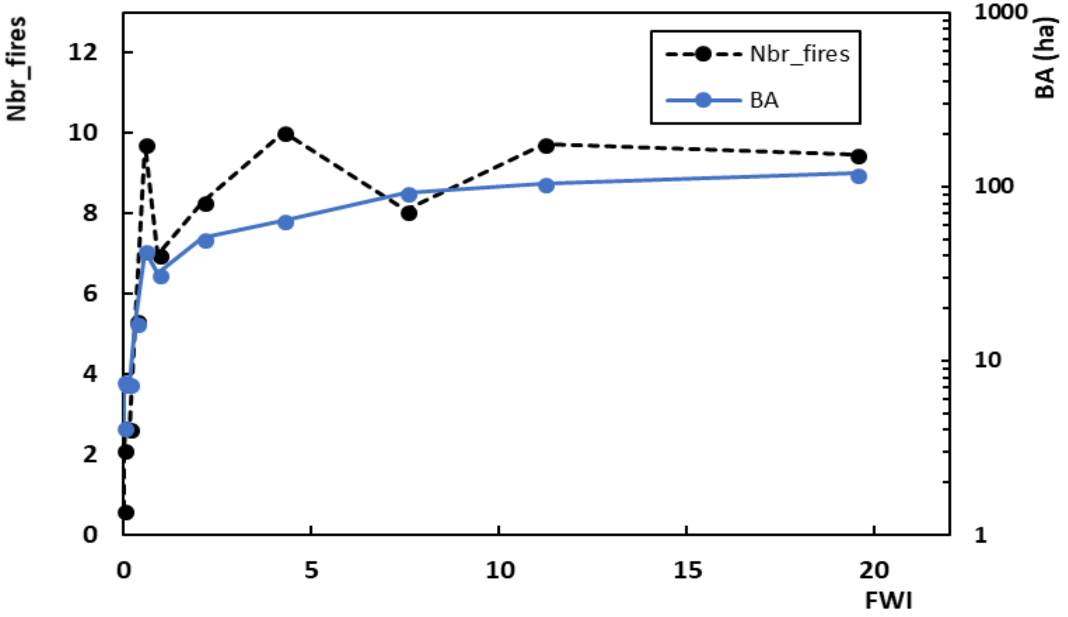


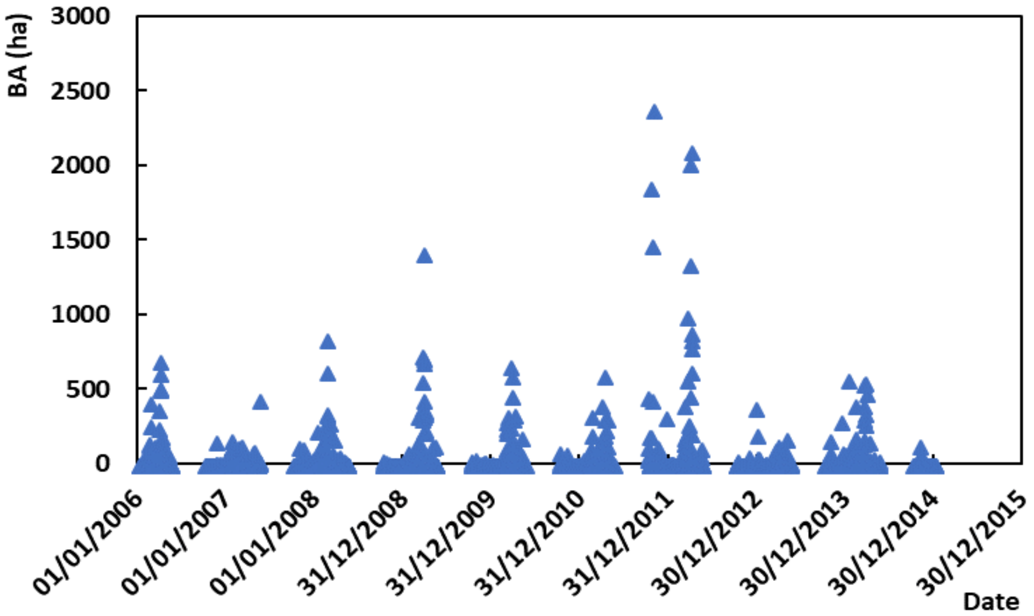
- Class C - Winter

ES120 (23/10/2011):

– Risk level: 3

– BA: 2374.6 ha

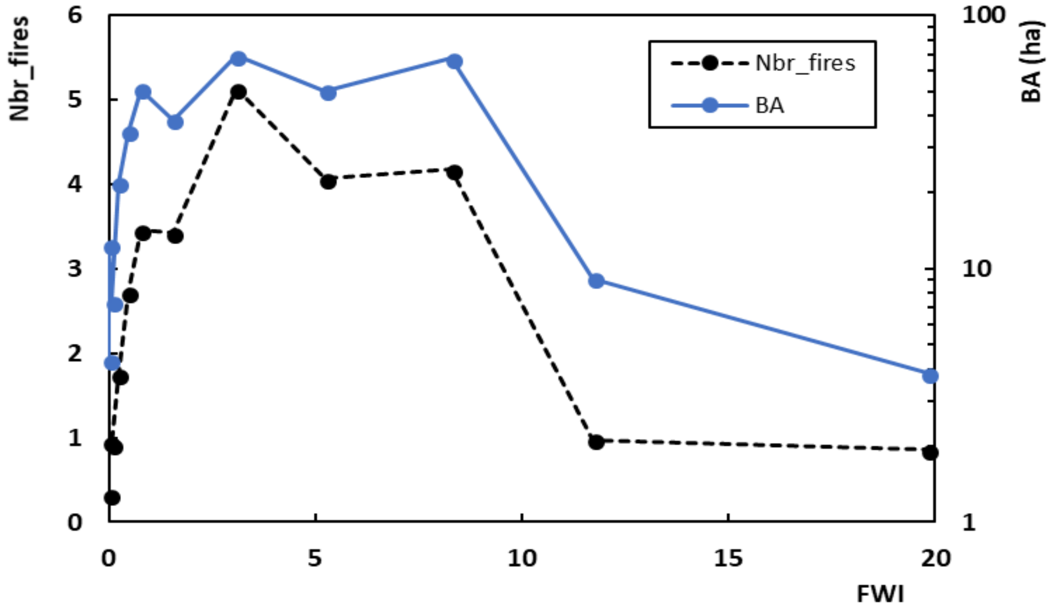


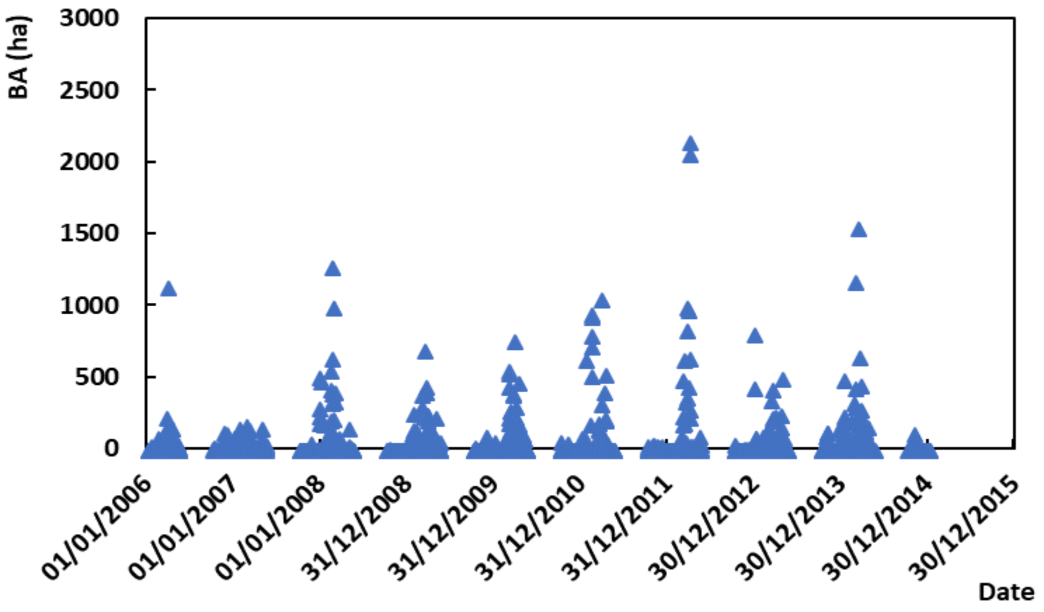


- Class C - Winter

ES130 (27/03/2012):

- Risk level: 2
- BA: 2146.5 ha





Conclusion

- A calibration of the forest fire danger based on the FWI values was established for the entire Europe.
- This calibration was based on the assumption of the existence of a monotnic relationship between FWI and the NF and BA, which is not always the case.
- We identified cases that require more attention namely the occurrence of very bad fire days and the winter fires.

8th INTERNATIONAL CONFERENCE ON

FOREST FIRE RESEARCH

Conference Chairman: Professor Domingos X. Viegas (ADAI, University of Coimbra, Portugal)

10 – 16 November 2018 ; Coimbra, Portugal

Conference Topics

A wide range of topics involved in this pluri-disciplinar problem can be covered by the authors during the Conference. Papers or posters dealing with the most relevant topics related to forest fires on a scientific basis will be accepted. These topics are only indicative therefore submissions can cover other relevant aspects:

- Human and Institutional factors
- Forest management and Fire Prevention
- Fire at the Wildland Urban Interface
- Forest Fire Risk assessment and Climate Change
- Fire Detection and Monitoring
- Remote Sensing
- Fire Management
- Fire Suppression and New technologies
- Large Fires
- Fire Safety
- Economic Issues
- Fire Ecology
- Evaluation and management of burned areas

Related events

V Short Course on Fire Safety(10 November 2018) | VIII Short Course on Fire Behaviour (11 November 2018)

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PORTUGAL

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Fax.: +351 239 790771
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Deadlines

The deadlines for participating in the Conference are:

- Presentation of Abstracts 15 February 2018
- Acceptance of Abstracts 30 April 2018
- Full version of Papers or Posters 30 June 2018
- Early Registration 30 September 2018
- Early Hotel Reservation 30 September 2018
- Definitive Program 31 October 2018

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3rd GWIS and GOGC-GOLD Fire IT Meeting

Fire Danger Enhancement and Calibration

Domingos Xavier Viegas with L. M. Ribeiro and D. Alves

Maryland 1st October 2018

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