Developing a fire danger information system for Scotland 2006 – 2022.

- a learning journey

Michael Bruce, Director, Firebreak Services Ltd

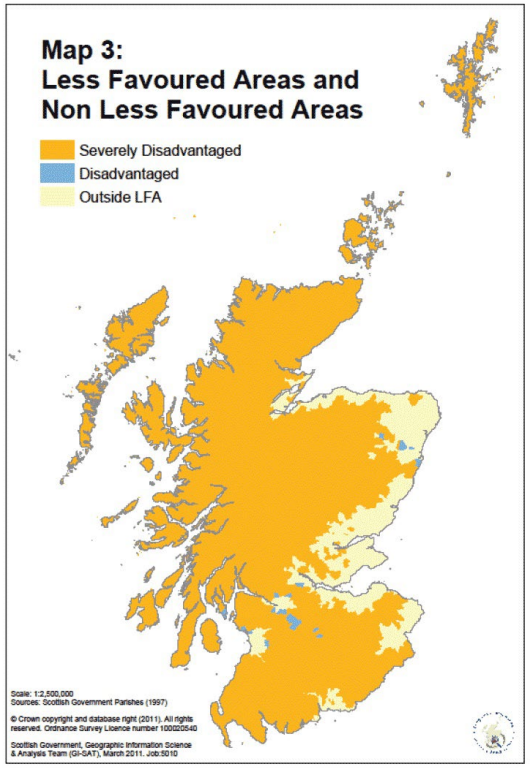
Nov 2022

Introduction- FDIS for Scotland

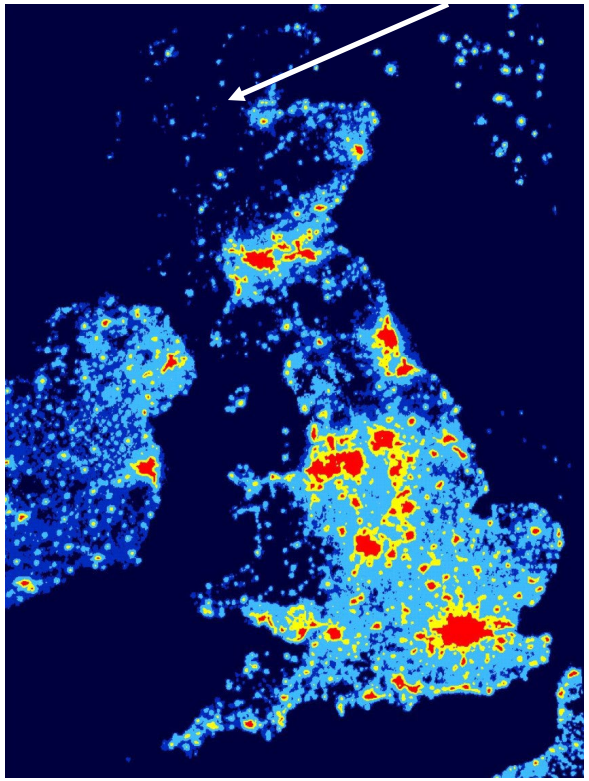
- The people and organisations involved
- The context of wildfire and Muirburn (prescribed burning) in Scotland
- The evolution of the Scottish fire danger information system
- Links with the Scottish Wildfire Forum Communications Strategy
- The future?
- Summary

Scottish FDIS context – the land and the people

The land that burns



Has few people (dark skies)



Scottish FDIS context – jurisdiction

- Scotland Act 1998 – set up the Scottish Parliament with a written constitution, with legislative powers devolved to the Scottish Parliament.
- The Scottish Parliament has the power to legislate (and therefore also fund) the following areas:
  - agriculture, forestry
  - environment
  - fire services
- UK/Westminster Parliament only retained reserved powers in specific areas, anything not covered reverts to the Scottish Parliament

History of Scottish FDIS

- 2004 - Formation of the Scottish Wildfire Forum
- 2005 - CRoW Act 2000 (England and Wales) Adoption of the Canadian Fire Weather Index (CFWI) for implementation of access restrictions as part of fire prevention, MOFSI based on FWI was born.
- 2006-08 -Scottish Government Firebeaters Research project (1st attempt at adaptation of FWI), identified:
  - Significant issues with using the FWI - no correlation between FWI and heather fire behaviour in Spring – the main wildfire season in Scotland
  - Correlation was found between FFMC and wildfire occurrence

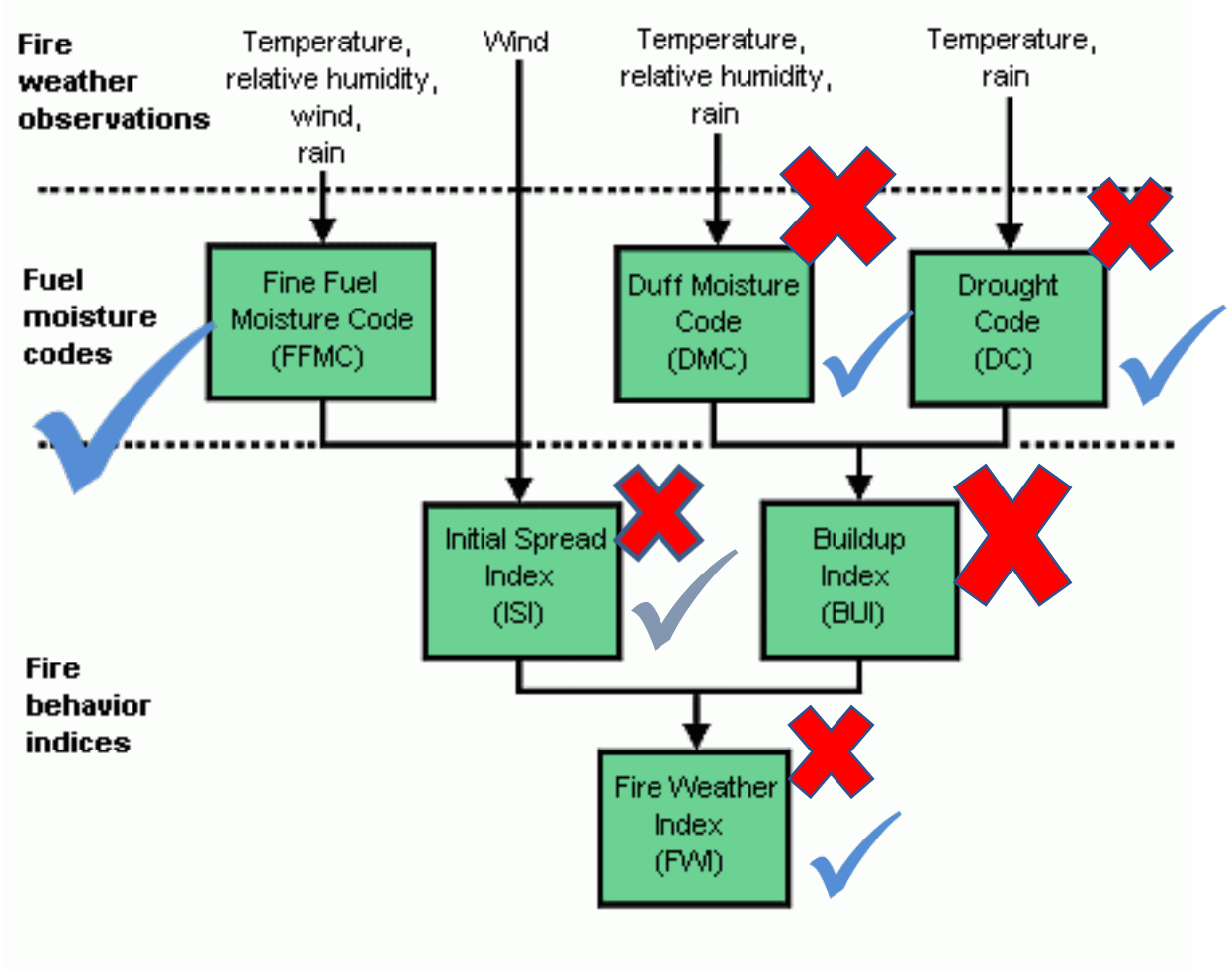
Evolution & development

- 2011 – Firebreak Services & Met Office Case Studies
- 2013 - Firebreak Services spring fire danger classes based on FFMC
- 2014 – Firebreak Services starts issuing Wildfire Danger Assessments (WDA) on behalf of Scottish Wildfire Forum
- 2016 – Davies & Legg analysis wildfire occurrence in relation to FFMC & ISI across the Scottish regions
- 2021 – Scottish Fire Danger Rating research project
- 2014 – 2022, WDA process refined, based on research, feedback & monitoring of *false positives and false negatives*

Wildfire Danger Assessment Process

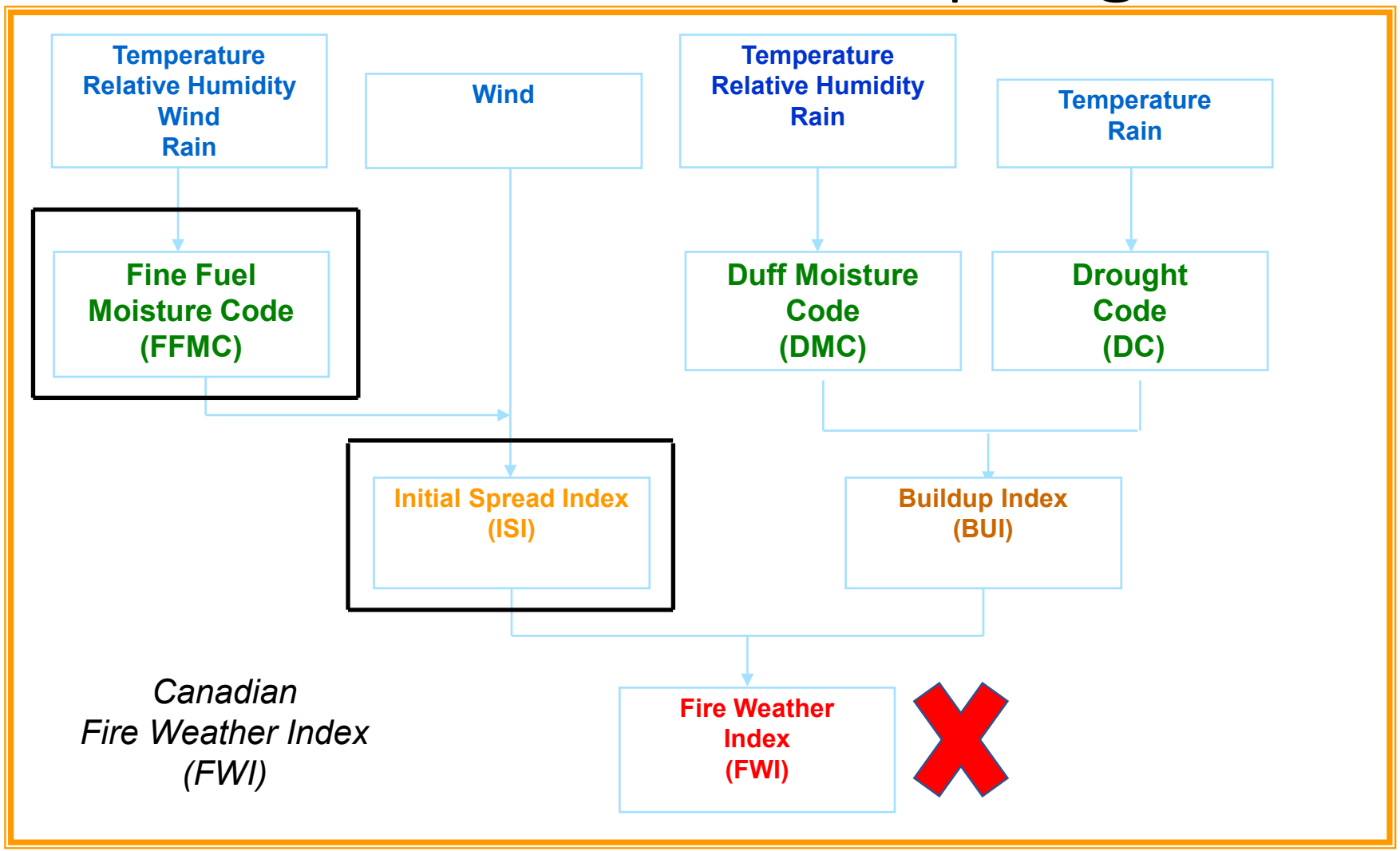
1. Check fuel type
2. Check seasonal condition of fuel types (including ground-truthing)
3. Obtain EFFIS fire weather maps & weather forecast information
4. Prepare wildfire danger assessment, and write interpretation
5. Share and discuss assessment with SFRS duty TacAd
6. Issue assessment
7. Obtain feedback

FWI system – so what works in UK?



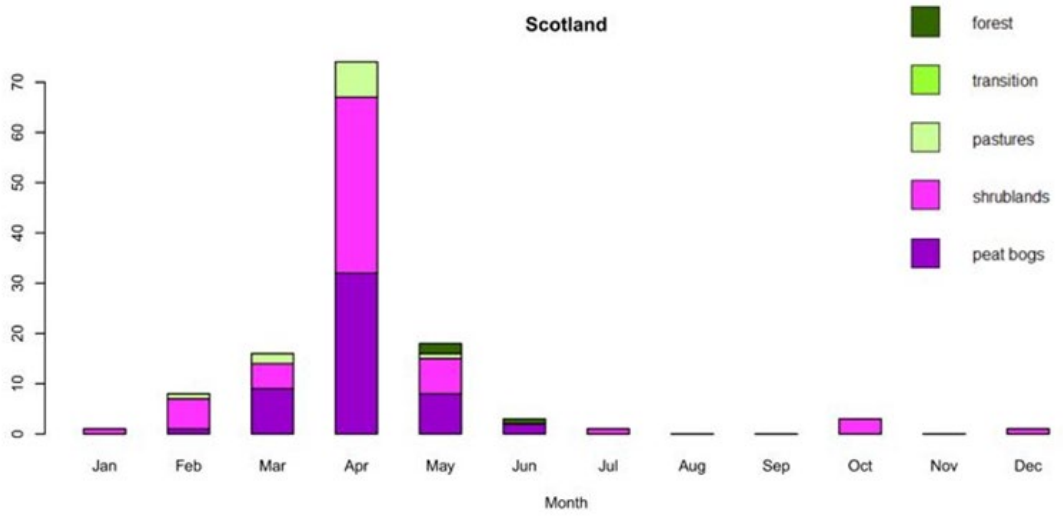
Key issue - FWI system not designed for shrub fuels

Fire Weather Sub-indexes FFMC & ISI used – most relevant in Autumn - Spring

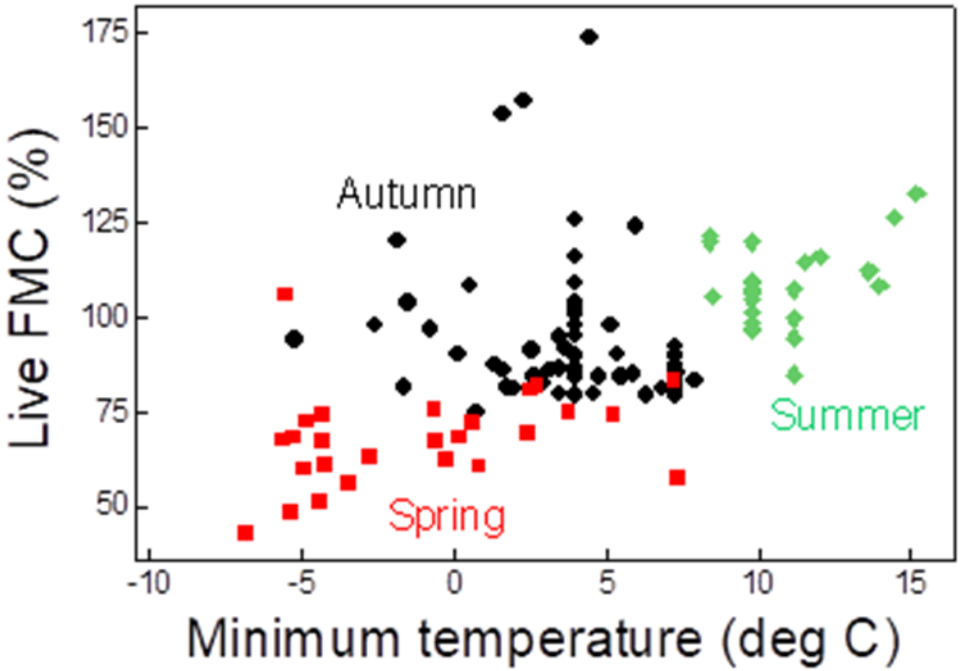


Wildfires – fuel type & seasonal (phenological) condition

3 clusters of fuel types: shrub/pasture, bog and forest



LFMC senescence, green-up & transition



FWI system & heather habitat fuel

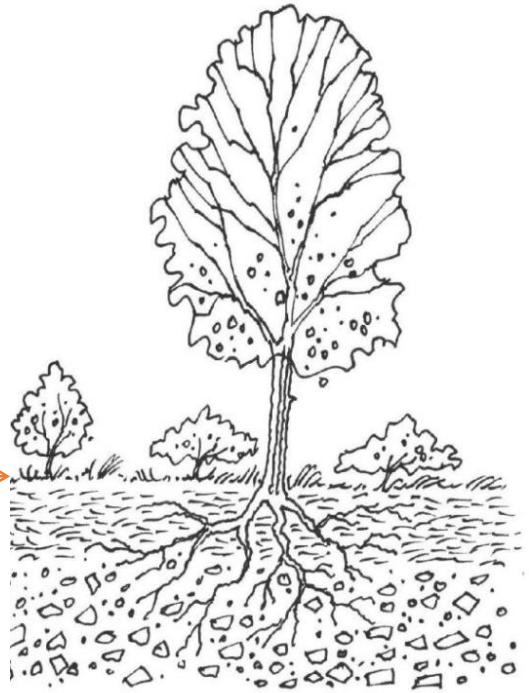
FWI sub-indices

No shrub layer moisture index

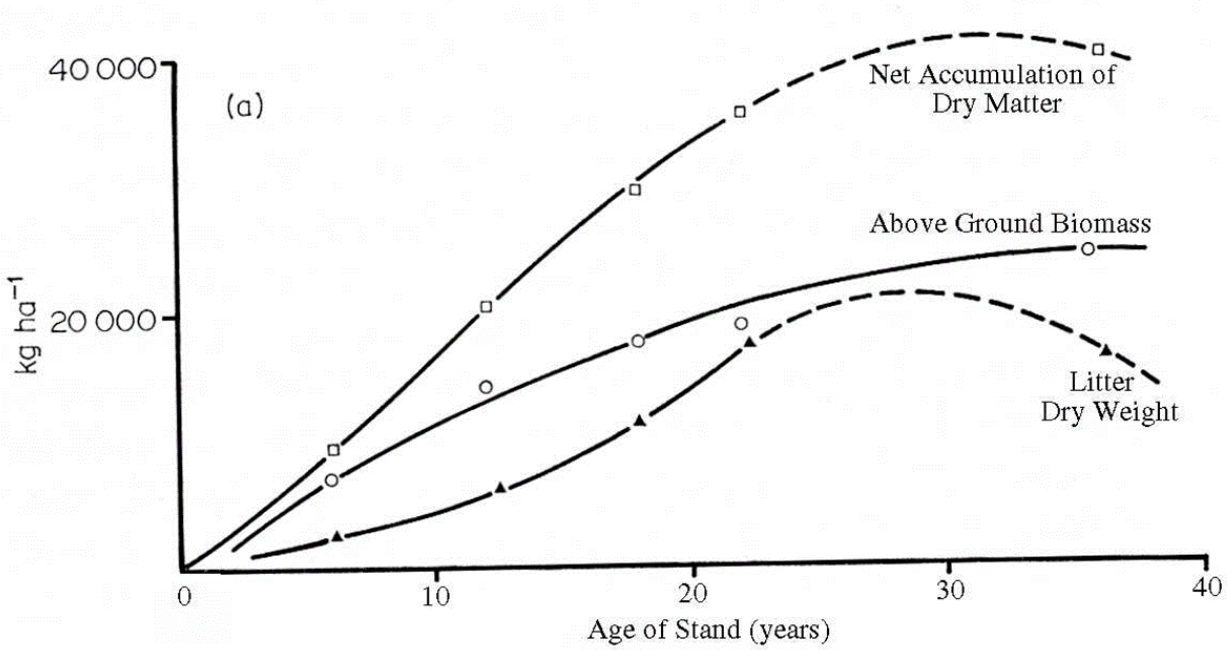
FFMC (1.2cm)

DMC (7cm)

DC (18cm)



Heather fuel layers



Flame length & threshold of control

Flame Lengths (m)	Significance
0 – 0.5	Fires generally self extinguish
0.5 - 1.5	Fire intensity low Hand tools can be used in direct attack to control the fire
1.5 - 2.5	Fire too intense for direct attack with hand tools Pumped water or bulldozers may be needed Flanking / parallel attack recommended
2.5 - 3.5	Fire too intense for direct attack from control line Helicopters & fixed wing aircraft drops may be needed Flanking / parallel attack depending on local flame length
3.5 - 8	Very intense fire Backburning and backfiring may knockdown the head fire Flanking / parallel and indirect attack recommended depending on local flame length.
8m+	Extreme fire behaviour Defensive strategies recommended

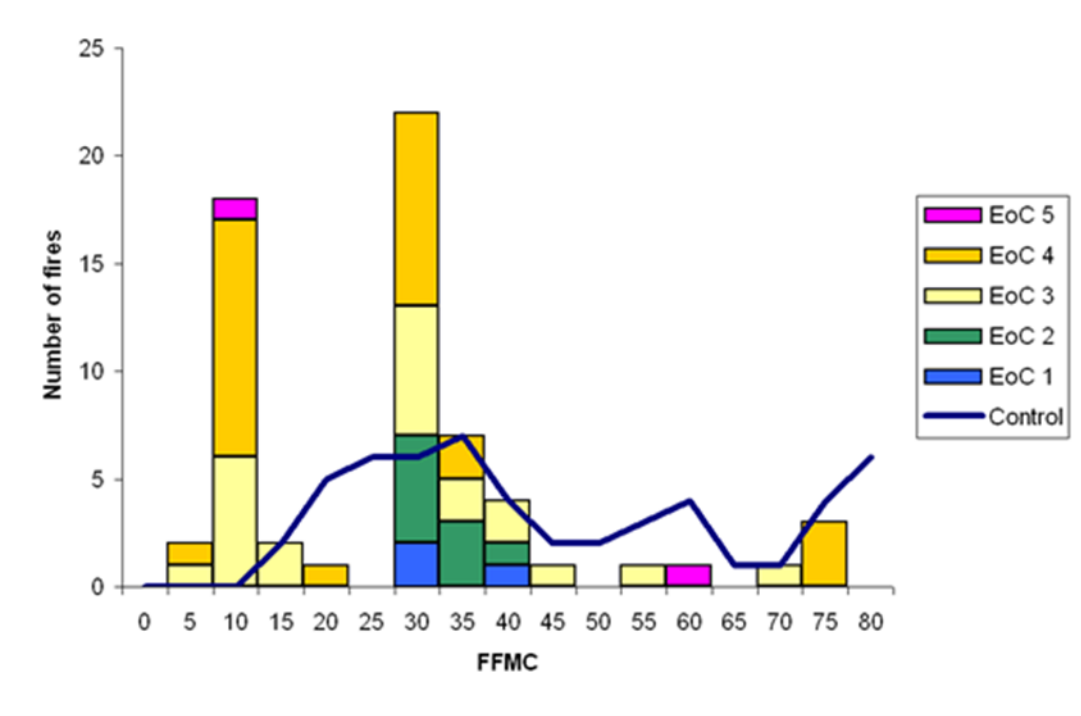
CFFDRS Fire Danger Classes/ Indicators

FWI Index values (kW/m)	FDR FWI class	Status	Description (Fire Danger Indicators)
< 10	2 – 4	Low	Fires likely to be self-extinguishing and new ignitions unlikely. Any existing fires limited to smoldering in deep, drier layers.
10 – 500	5 – 8	Moderate	Creeping or gentle surface fires. Fires easily contained by ground crews with pumps and hand tools.
500 – 2000	9 - 16	High	Moderate to vigorous surface fire with intermittent crown involvement. Challenging for ground crews to handle; heavy equipment (bulldozers, tanker trucks, aircraft) often required to contain fire.
2000 – 4000	17 - 29	Very High	High-intensity fire with partial to full crown involvement. Head fire conditions beyond the ability of ground crews; air attack with retardant required to effectively attack fire's head.
> 4000	30 +	Extreme	Fast-spreading, high-intensity crown fire. Very difficult to control. Suppression actions limited to flanks, with only indirect actions possible against the fire's head.

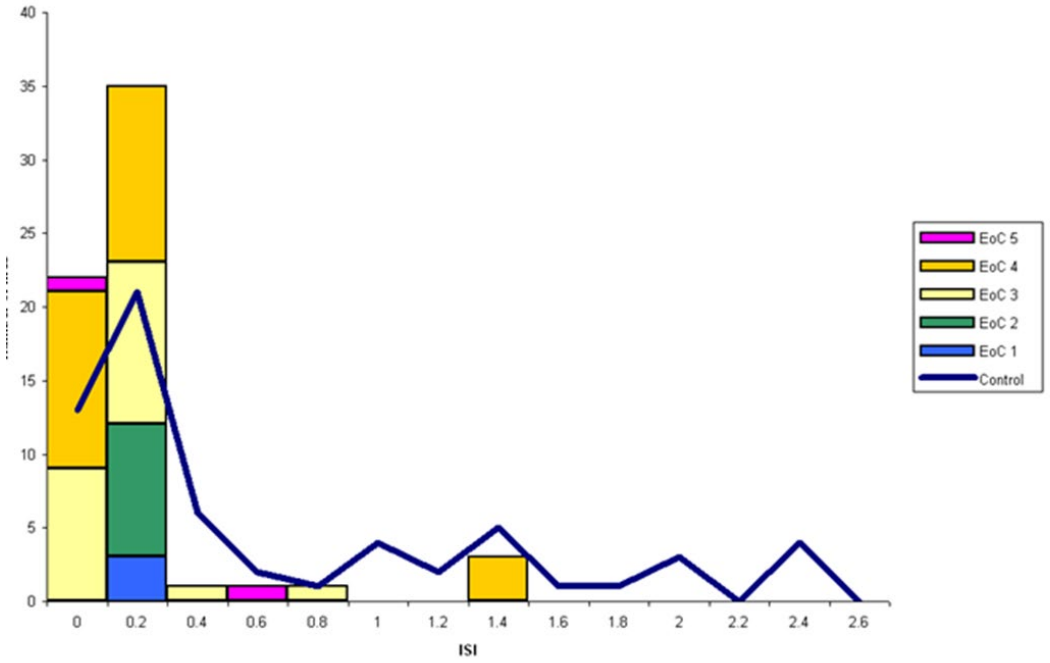
Gamekeepers burning – ease of control

(Firebeaters participatory research 2007)

Low FFMC

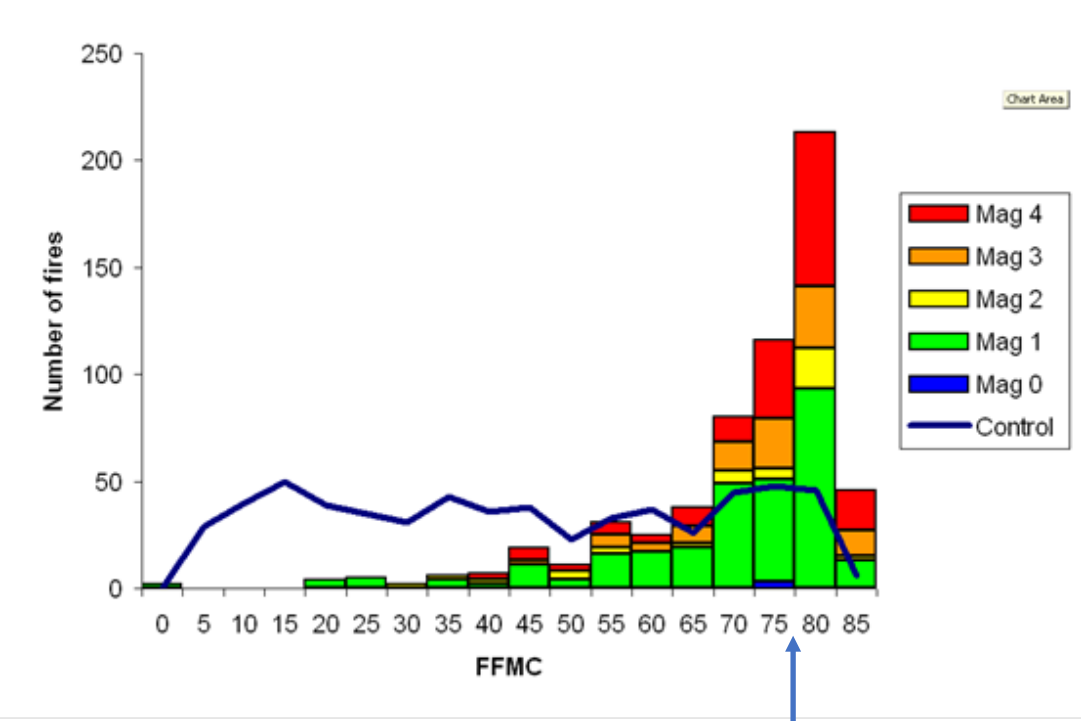


Low ISI

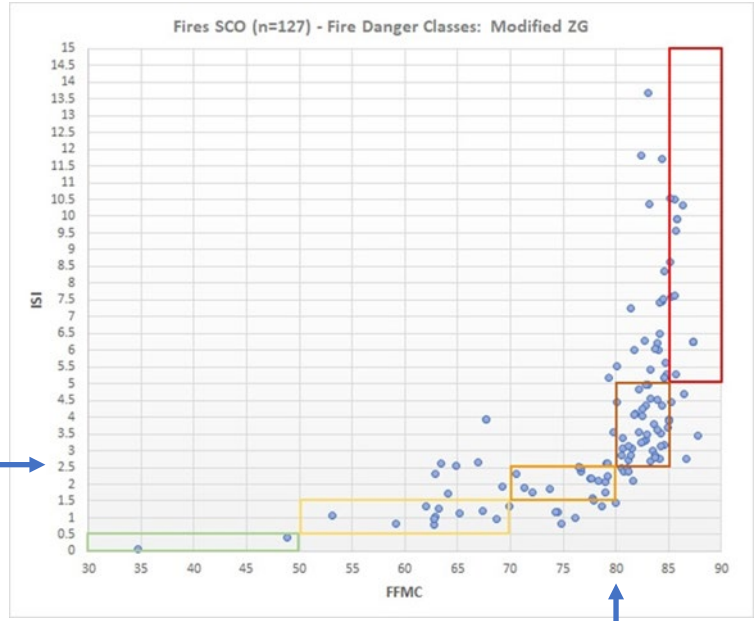


Magnitude of fires & fire danger bands

Number & magnitude fires 2003-7

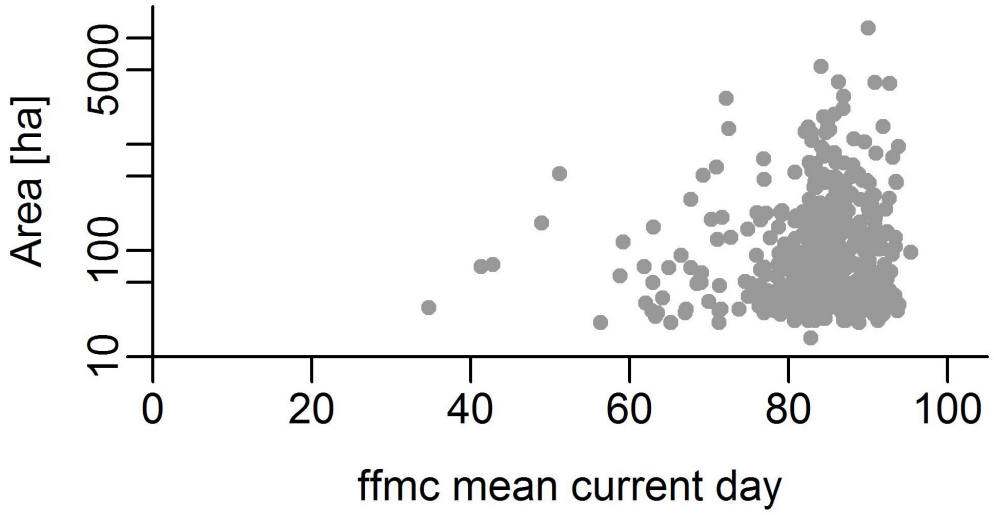


Spring fires Scotland >30 ha 2013-19

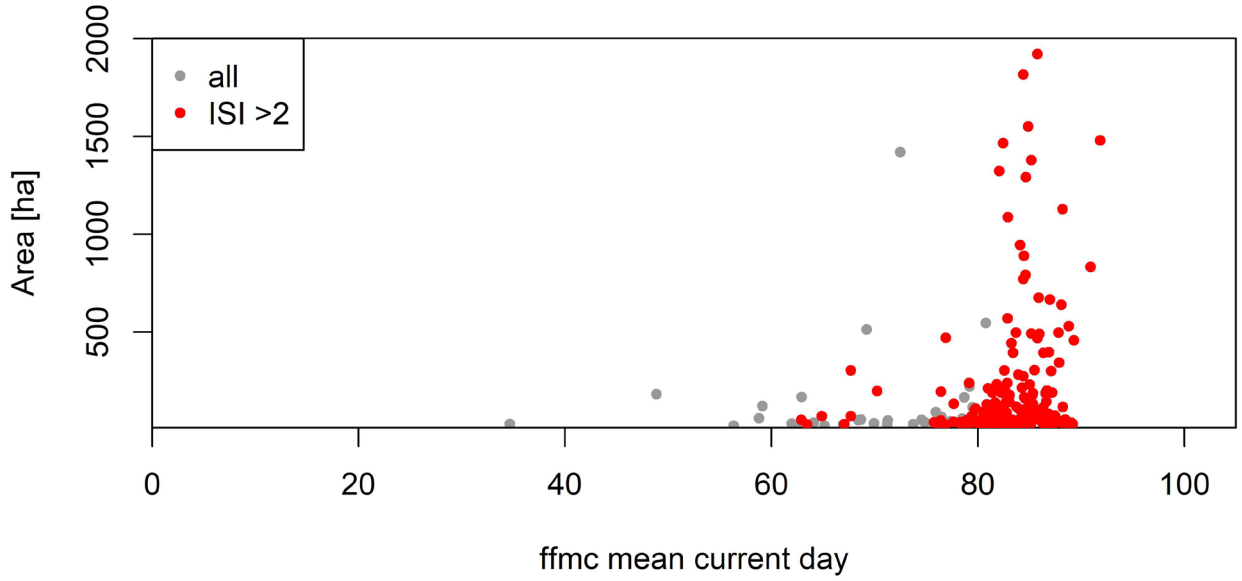


Scottish wildfires - Fine Fuel Moisture Code & Initial Spread Index

FFMC



FFMC + ISI



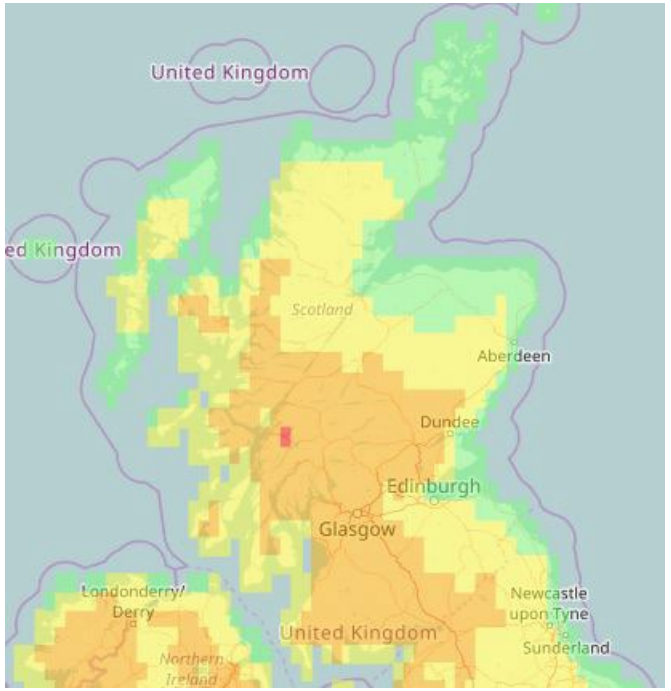
Scottish Wildfire Forum
- wildfire hazard assessments

EFFIS FFMC FDR SFDIS bands (SFDRS research)

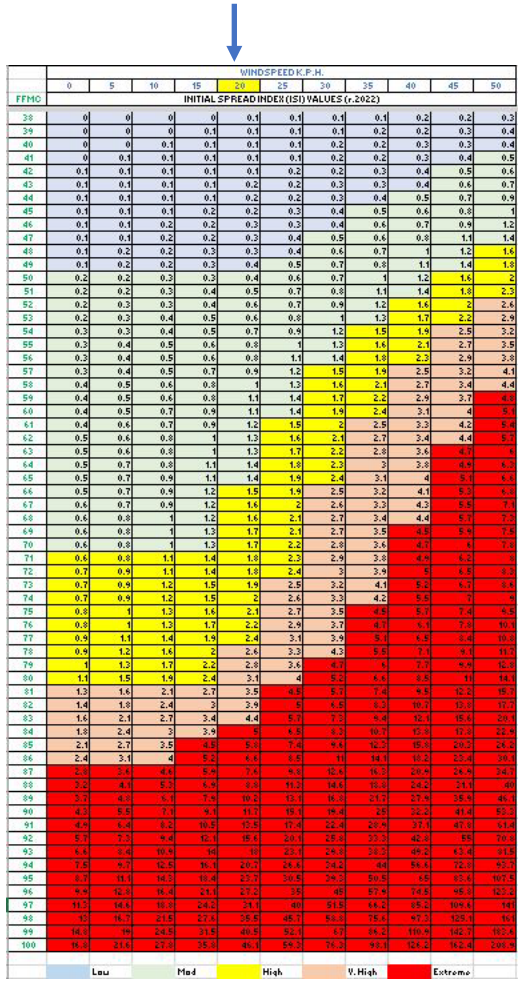
Draft Fire Danger Class Bands	Scotland FFMC	Scotland ISI	EFFIS FFMC	EFFIS ISI	EFFIS colours	Scotland colours
Low	<50	<0.5	<82.7	<3.2	Green	
Mod	50 - 70	0.5 - <1.5	82.7-86.1	3.2-5	Yellow	Very High
High	70 - 80	1.5 > - <2.5	86.1-89.2	5-7.5	Brown	Extreme
Very high	80 - 85	2.5 > - <4.5	89.2-93	7.5-13.4	Red	
Extreme	>85	4.5>	>93	>13.4	Black	

- Issues with mis-match between fire danger bands & colours – false positives & negatives

EFFIS forecast map + spot info FFMC > 80



Spring fire danger classes – updated look-up table

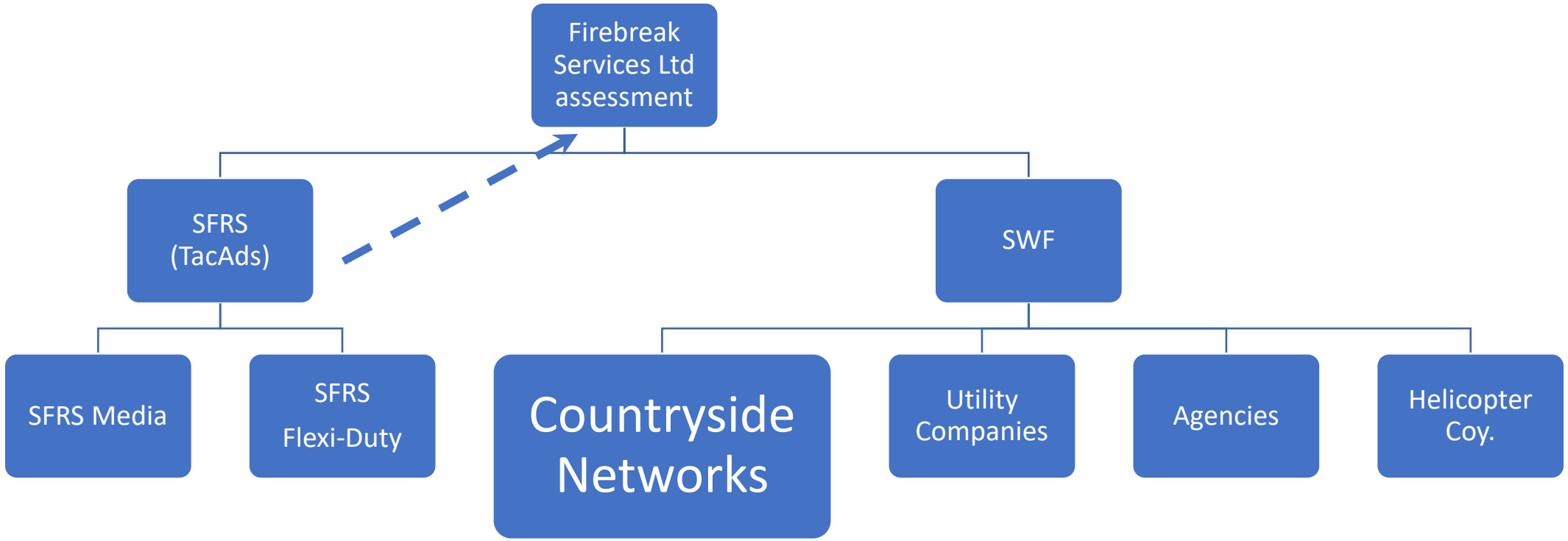


	WINDSPEED K.P.H.										
	0	5	10	15	20	25	30	35	40	45	50
FFMC	INITIAL SPREAD INDEX (ISI) VALUES (r.2022)										
38	0	0	0	0	0.1	0.1	0.1	0.1	0.2	0.2	0.3
39	0	0	0	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.4
40	0	0	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4
41	0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.5
42	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
43	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7
44	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.9
45	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1
46	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9	1.2
47	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.1	1.4
48	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	1	1.2	1.6
49	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8	1.1	1.4	1.8
50	0.2	0.2	0.3	0.3	0.4	0.6	0.7	1	1.2	1.6	2
51	0.2	0.2	0.3	0.4	0.5	0.7	0.8	1.1	1.4	1.8	2.3
52	0.2	0.3	0.3	0.4	0.6	0.7	0.9	1.2	1.6	2	2.6
53	0.2	0.3	0.4	0.5	0.6	0.8	1	1.3	1.7	2.2	2.9
54	0.3	0.3	0.4	0.5	0.7	0.9	1.2	1.5	1.9	2.5	3.2
55	0.3	0.4	0.5	0.6	0.8	1	1.3	1.6	2.1	2.7	3.5
56	0.3	0.4	0.5	0.6	0.8	1.1	1.4	1.8	2.3	2.9	3.8
57	0.3	0.4	0.5	0.7	0.9	1.2	1.5	1.9	2.5	3.2	4.1
58	0.4	0.5	0.6	0.8	1	1.3	1.6	2.1	2.7	3.4	4.4
59	0.4	0.5	0.6	0.8	1.1	1.4	1.7	2.2	2.9	3.7	4.8
60	0.4	0.5	0.7	0.9	1.1	1.4	1.9	2.4	3.1	4	5.1
61	0.4	0.6	0.7	0.9	1.2	1.5	2	2.5	3.3	4.2	5.4
62	0.5	0.6	0.8	1	1.3	1.6	2.1	2.7	3.4	4.4	5.7
63	0.5	0.6	0.8	1	1.3	1.7	2.2	2.8	3.6	4.6	6
64	0.5	0.7	0.8	1.1	1.4	1.8	2.3	3	3.8	4.8	6.2
65	0.5	0.7	0.9	1.1	1.4	1.9	2.4	3.1	4	5.1	6.6
66	0.5	0.7	0.9	1.2	1.5	1.9	2.5	3.2	4.1	5.3	6.8
67	0.6	0.7	0.9	1.2	1.6	2	2.6	3.3	4.3	5.5	7.1
68	0.6	0.8	1	1.2	1.6	2.1	2.7	3.4	4.4	5.7	7.3
69	0.6	0.8	1	1.3	1.7	2.1	2.7	3.5	4.5	5.9	7.6
70	0.6	0.8	1	1.3	1.7	2.2	2.8	3.6	4.7	6	7.8
71	0.6	0.8	1.1	1.4	1.8	2.3	2.9	3.8	4.9	6.2	8
72	0.7	0.9	1.1	1.4	1.8	2.4	3	3.9	5	6.5	8.3
73	0.7	0.9	1.2	1.5	1.9	2.5	3.2	4.1	5.2	6.7	8.6
74	0.7	0.9	1.2	1.5	2	2.6	3.3	4.2	5.5	7	9
75	0.8	1	1.3	1.6	2.1	2.7	3.5	4.5	5.7	7.4	9.5
76	0.8	1	1.3	1.7	2.2	2.9	3.7	4.7	6.1	7.9	10.1
77	0.9	1.1	1.4	1.9	2.4	3.1	3.9	5.1	6.5	8.4	10.8
78	0.9	1.2	1.6	2	2.6	3.3	4.3	5.5	7.1	9.1	11.7
79	1	1.3	1.7	2.2	2.8	3.6	4.7	6	7.7	9.9	12.8
80	1.1	1.5	1.9	2.4	3.1	4	5.2	6.6	8.5	11	14.1
81	1.3	1.6	2.1	2.7	3.5	4.5	5.7	7.4	9.5	12.2	15.7
82	1.4	1.8	2.4	3	3.9	5	6.5	8.3	10.7	13.8	17.7
83	1.6	2.1	2.7	3.4	4.4	5.7	7.3	9.4	12.1	15.6	20.1
84	1.8	2.4	3	3.9	5	6.5	8.3	10.7	13.8	17.8	22.9
85	2.1	2.7	3.5	4.5	5.8	7.4	9.5	12.2	15.8	20.3	26
86	2.4	3.1	4	5.2	6.6	8.5	11	14.1	18.2	23.4	30.1
87	2.8	3.6	4.6	5.9	7.6	9.8	12.6	16.3	20.9	26.9	34.6
88	3.2	4.1	5.3	6.9	8.9	11.3	14.6	18.8	24.2	31.1	40
89	3.7	4.8	6.1	7.9	10.2	13.1	16.9	21.7	27.9	35.9	46.1
90	4.3	5.5	7.1	9.1	11.7	15.1	19.4	25	32.2	41.4	53.2
91	4.9	6.4	8.2	10.5	13.5	17.4	22.4	28.9	37.1	47.8	61.4
92	5.7	7.3	9.4	12.1	15.6	20.1	25.8	33.3	42.8	55	70.8
93	6.6	8.4	10.9	14	18	23.1	29.8	38.3	49.2	63.4	81.5
94	7.5	9.7	12.5	16.1	20.8	26.8	34.5	44	56.6	72.8	93.7
95	8.7	11.1	14.3	18.4	23.7	30.5	39.3	50.5	65	83.6	107.5
96	9.9	12.8	16.4	21.1	27.2	35	45	57.9	74.5	95.9	123.3
97	11.3	14.6	18.8	24.2	31.1	40	51.5	66.2	85.2	109.6	141
98	13	16.7	21.5	27.6	35.5	45.7	58.8	75.6	97.3	125.1	161
99	14.8	19	24.5	31.5	40.5	52.1	67	86.2	110.9	142.7	183.4
100	16.8	21.6	27.8	35.8	46.1	59.3	76.3	98.1	126.2	162.4	208.8

Low Mod High V.High Extreme

- Developed from SFDRS research project analysis on wildfires
- Used in wildfire danger assessments
- As risk management guidance & training for Muirburn operators
- Muirburn Code traditional knowledge 20 kph key transition to higher fire danger

Distribution of Wildfire Danger Assessments



Communication of fire danger warnings by Scottish Wildfire Forum in Scotland

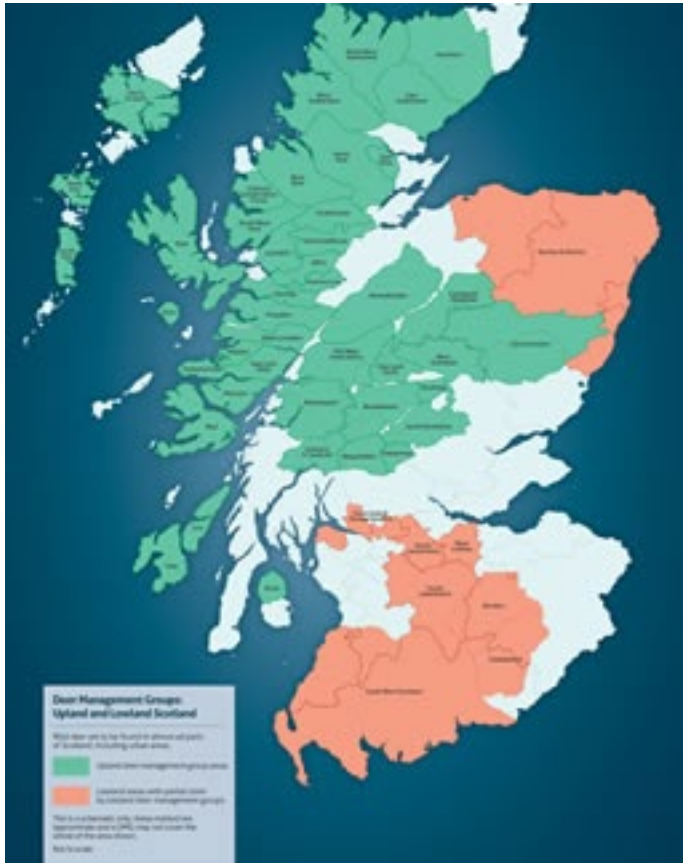
- Database driven “push” of assessments through communication chains to land managers, agency staff and utility company control rooms
- Co-ordination with Scottish Fire and Rescue Service, both at senior operational level (Wildfire TacAds) and with media team to send out “public message”
- Co-ordination of messages among agency media professionals (SWF communications strategy)
- Specific messages developed for different target audiences – e.g. regions, national parks & land managers – massive media response
- Specific support for high risk communities e.g. Crofting Grazing Committees on the Island of Skye

Public messaging – prevention - coherent repetition to raise awareness





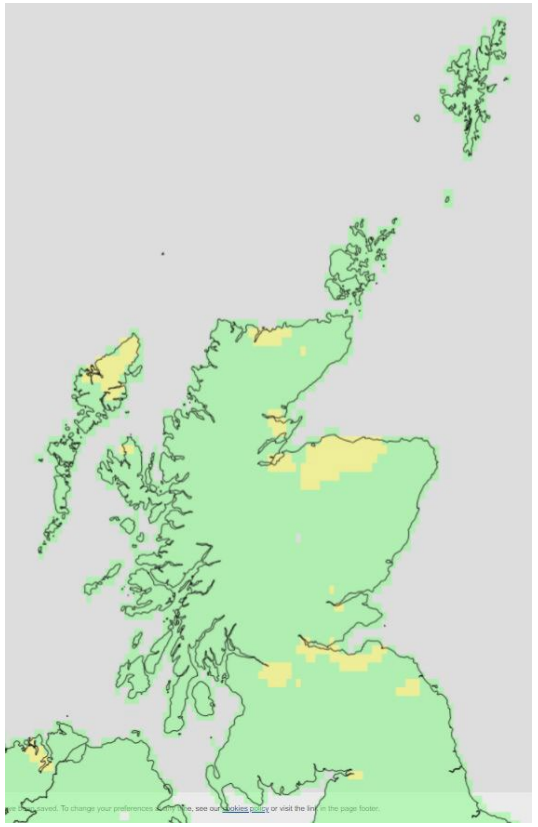
Scottish Countryside Networks



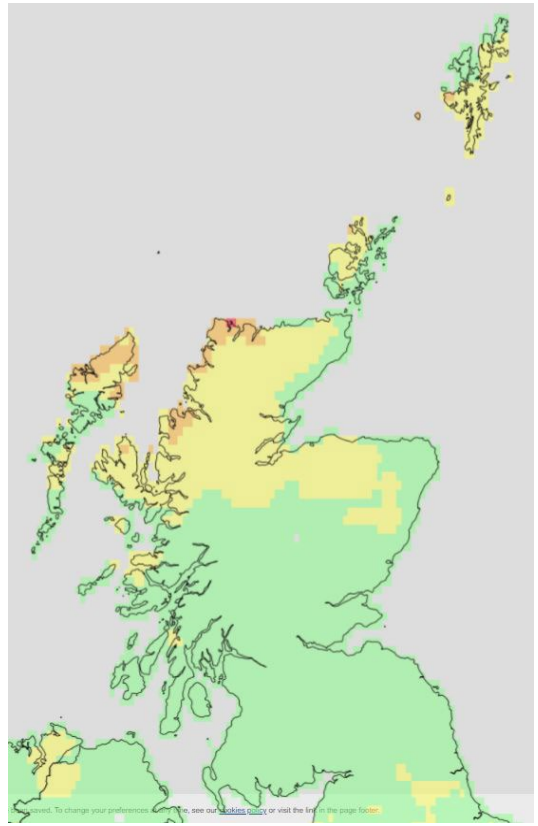
- Wildfire groups, Deer management groups, moorland groups
- Trade associations: SLE, NFUS, Confor, Scottish Crofters Foundation, Wildfire groups, moorland groups
- National Parks, Scottish Countryside Rangers Ass.

EFFIS maps, regional variation – linked to interpretation & preparedness

FFMC 23/03/2022



ISI 23/03/2022



Preparedness

SFRS **&** **Private sector**

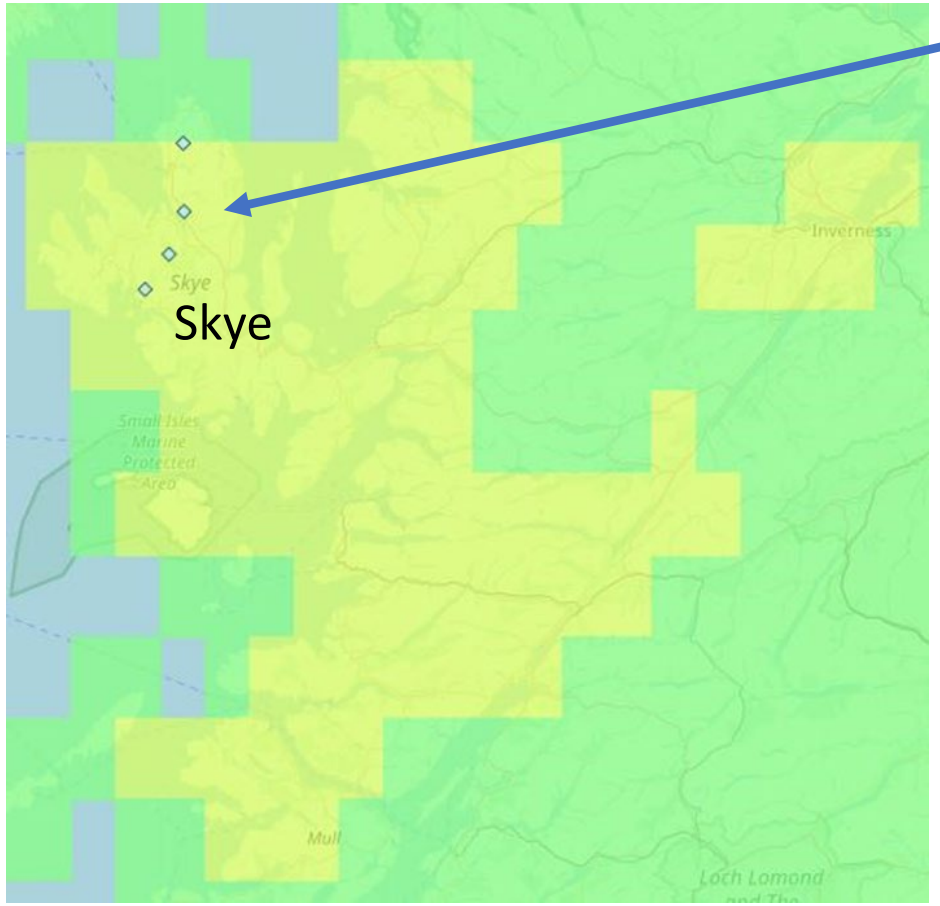




Spate of wildfires Skye 1st – 3rd March 2018

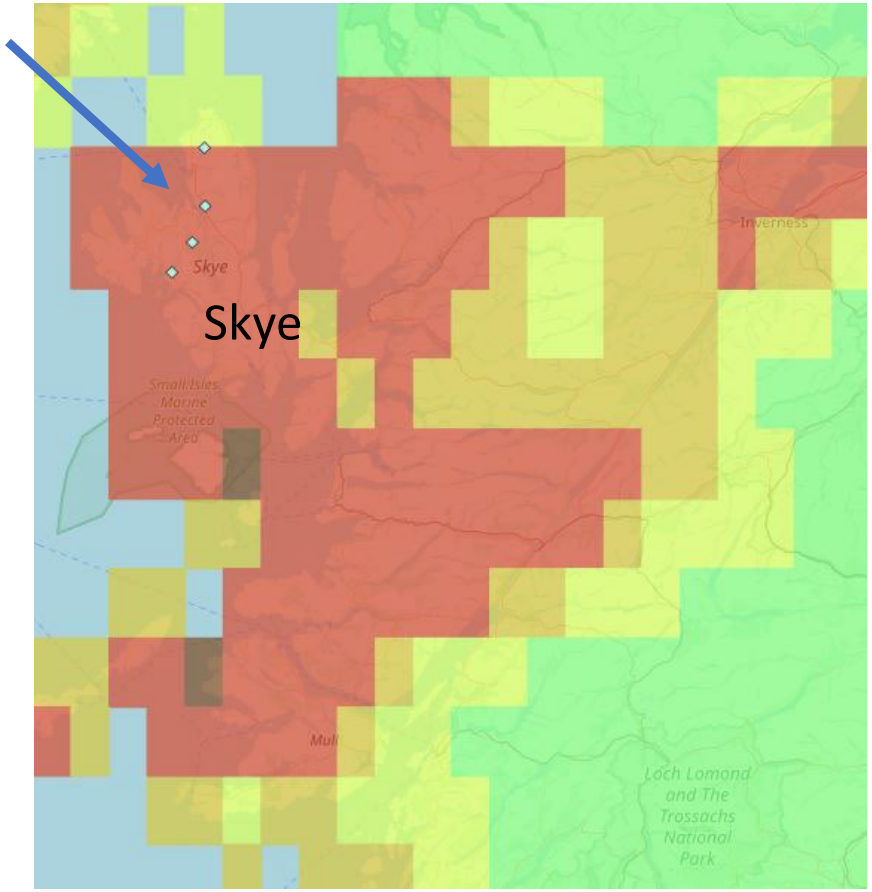
"Beast from the East" (Snow & gales) 1/3/18 ……Wildfires in the West
(Wildfire danger assessment issued)

Fine Fuel Moisture Code (FFMC)



Wildfires

Initial Spread Index (ISI)



Prescribed burning
- fire danger information & fire prescriptions



- Muirburn usually done at low FFMC & ISI
- Locality information on FFMC & ISI available from EFFIS
- Fire danger information can be built into escalating risk mitigation measures and go / no-go decisions, based on fire danger classes
- The information and process is being built into guidance and training material

Fire Danger Rating Systems

"A fire danger rating system (FDRS) is an assessment of both fixed and variable factors of the fire environment which determine:

- ease of ignition,
- rate of spread,
- difficulty of control
- and fire impact."

(Alexander & Merrill 1987)

FWI system uses :

Uses in UK

- Fire prevention planning
- Preparedness planning
- Prescribed Fire planning & execution
- Suppression tactics & strategies on wildfires
- Escaped fire situation analysis

Still to start uses

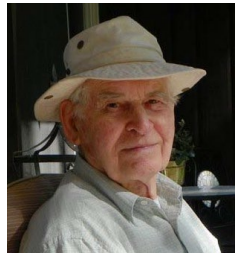
- Fire behaviour training
- Detection planning
- Initial attack despatching

Goal of Fire Danger Rating Research

- *"Make an index such that any given value will represent the same fire behaviour, no matter what weather history leads to it.*

  This is a very stiff test… The trouble is one very quickly outruns the available practical knowledge."

  (Van Wagner 1970)



- *"The fact is that it's difficult to portray all the aspects of fire danger in a single number… One number can't be expected to cover the full range of fire management needs."*

  (Alexander 1994)



Conclusions

- Fire danger information that is “good enough” has many applications and benefits
- Science has made progress but it takes time
- Still rely on experience, intuition and networks
- Respectful culturally aware consistent communication is essential
- End-users need to be part of the fire danger intelligence system
- Adaptive management keeps progress going!

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