Mapping and managing UK wildfire risk:

Geospatial science and knowledge exchange

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NERC SCIENCE OF THE ENVIRONMENT

Structure

1. **Wildfires as a socio-ecological hazard in the UK** – what, when, where, why, 'so what'
2. **Challenges for policy and practice**
3. **Knowledge for Wildfire** knowledge exchange project
4. **Applied geospatial research** to improve the evidence base for UK wildfire
   - Defining wildfire from national fire statistics
   - Wildfire Threat Analysis evaluation for forest-urban interface in SE England
   - Remote sensing of vegetation fire

What, where, when, why, significance

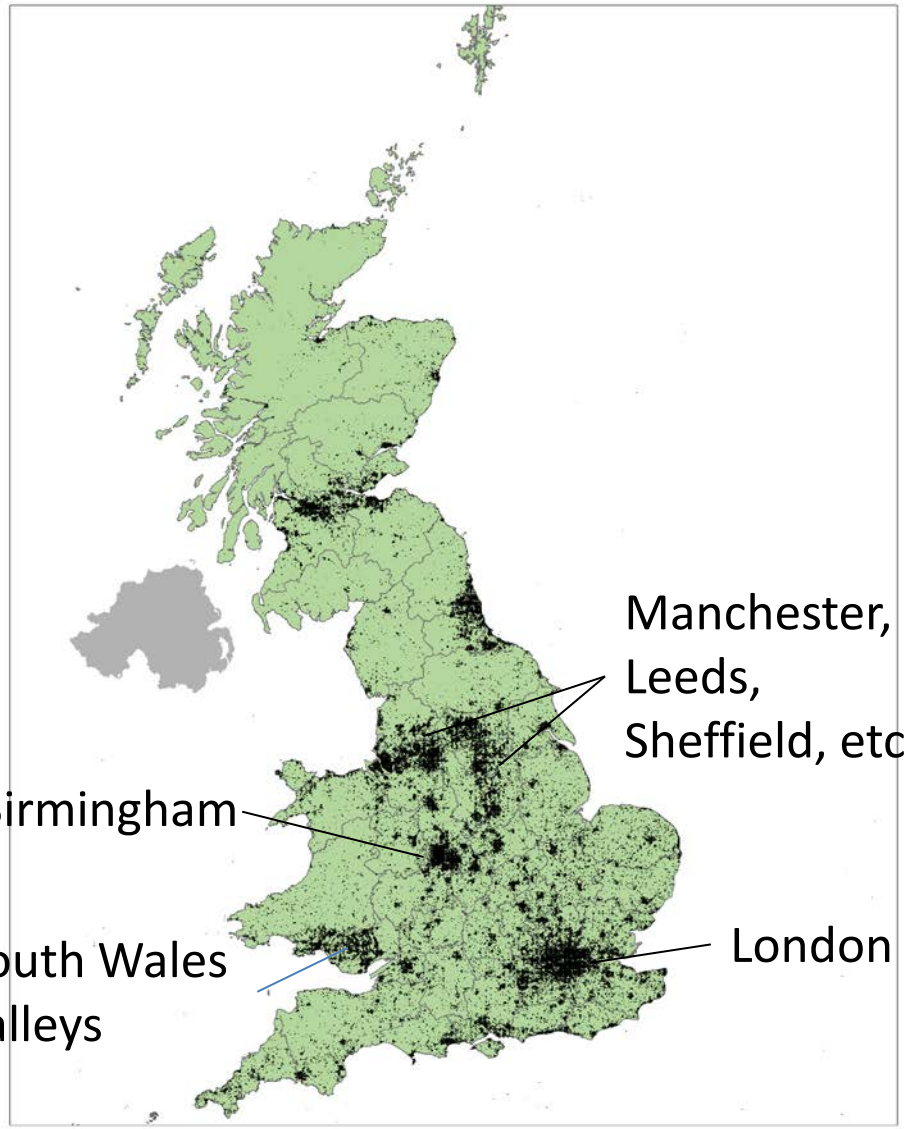
1. WILDFIRES AS A SOCIO-ECOLOGICAL HAZARD IN THE UK

Wildfires in the UK?

- '*Any uncontrolled vegetation fire which requires a decision or action regarding suppression*'
- About 55,000 pa, all sizes from <5m^2 to 70 km^2
- On moorlands (heather, scrub, grassland, peat) and rural-urban interface (RUI)

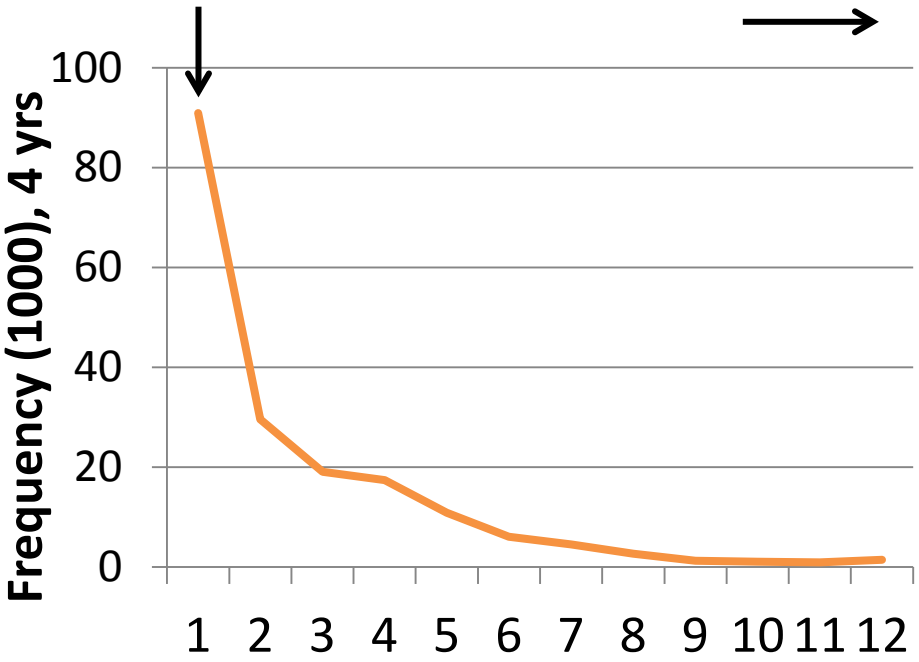
Most are rural-urban interface fires

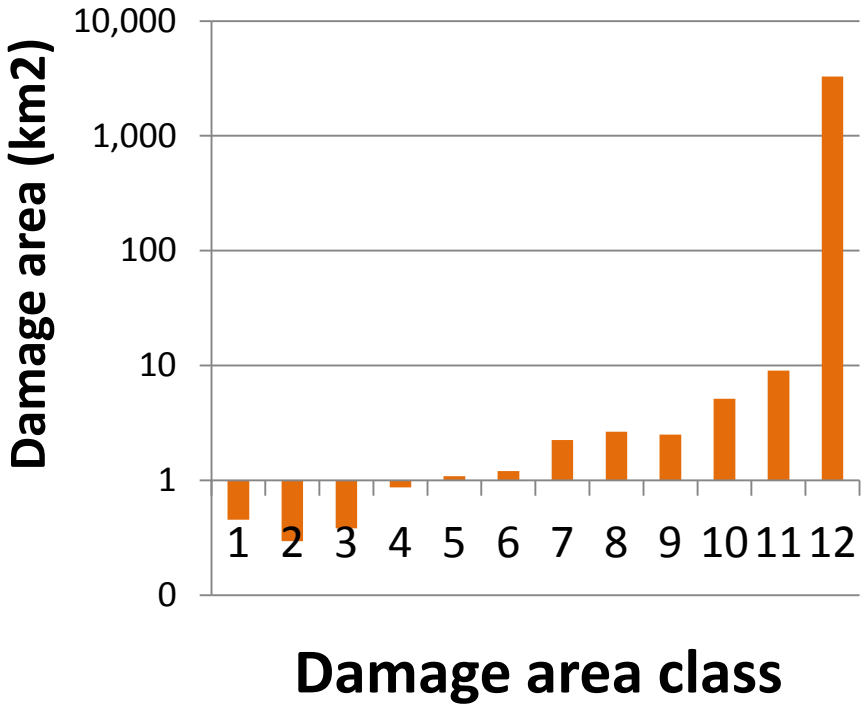
- Fire Service Incident Recording System (IRS); point data
- 18 IRS vegetation fire categories
- 4 Financial Years from 1st Apr 2009 – 31st Mar 2013 for GB (England, Wales, Scotland)
- Value for GIS analysis



How many, how large?

McMorrow *et al.* (2015)





- 49% of fires are <5 m^2 (class 1), but only < 0.1% of damage area. Rural-urban interface fires; tree scrub, grassland.
- <0.7% are >1ha (class 10); account for > 96% damage area. Open habitats; almost half are moorland /heath. Largest 70 km^2
- Location is more important than burnt area; RUI & peat moorland

Why: causes

Almost all caused by people

- Arson
- BBQs, litter, sky lanterns
- Sparks from machinery & vehicles, sky lanterns, cigarettes
- Escaped land management burns


BBC NEWS | LIVE | BBC NEWS CHANNEL

Last Updated: Friday, 18 April, 2003, 11:02 GMT 12:02 UK

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Peak fire could be arson

Peak fire could be arson

District National Park could have been started deliberately.

Park officials believe the fire at Kinder Scout could be suspicious and an investigation is being carried out.

Helicopters are pouring water on the fires


The Telegraph

April 2012

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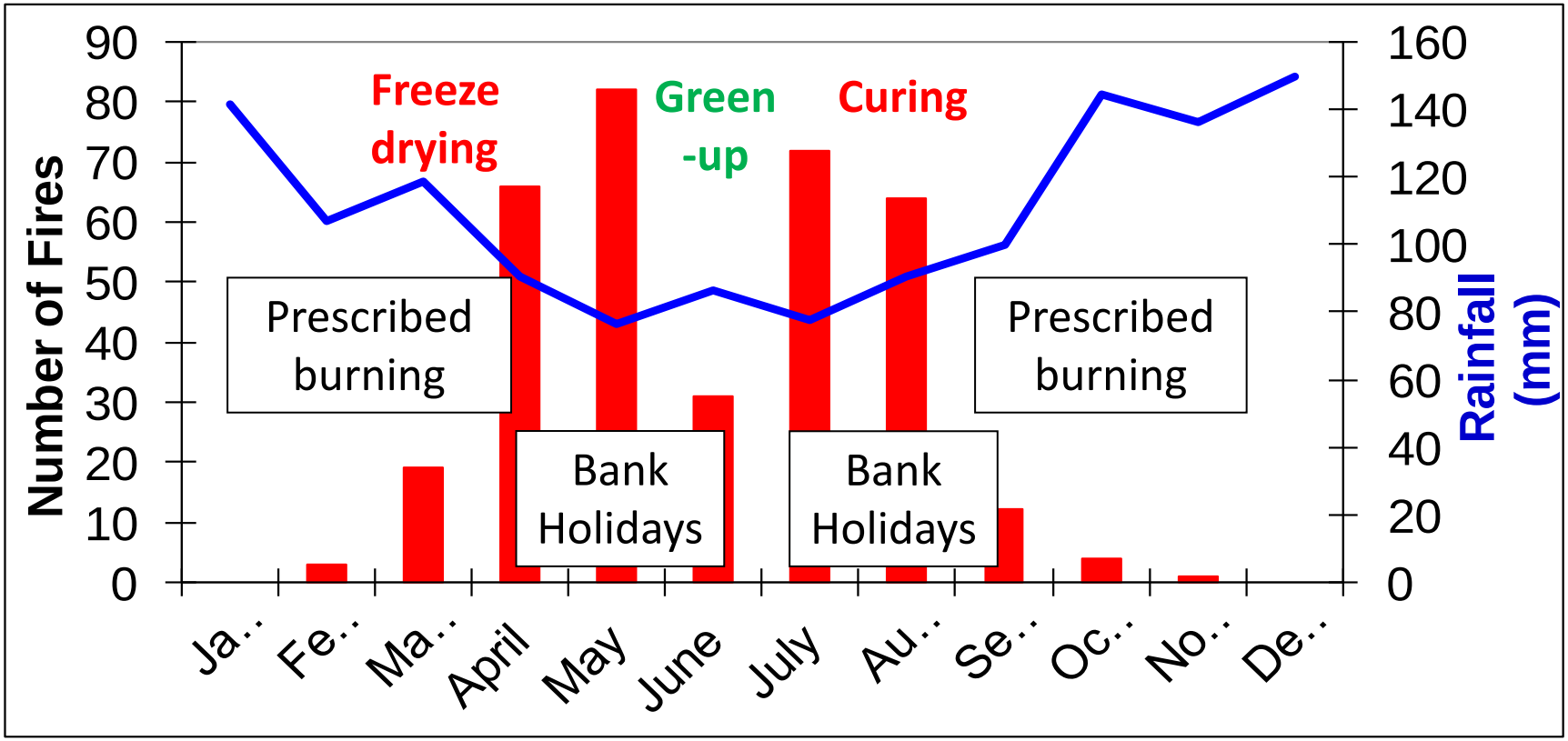
Wildfires across Highlands and Islands spark warning to land managers

Click here for Further information

When: spring & summer fire seasons

- Socio-ecological hazard; seasonality of climate + vegetation + human activity



Peak District, Number of fires by month 1975-2004
(Albertson *et al*., 2009; McMorrow et al. 2009)

- But high inter-annual variability

Significance

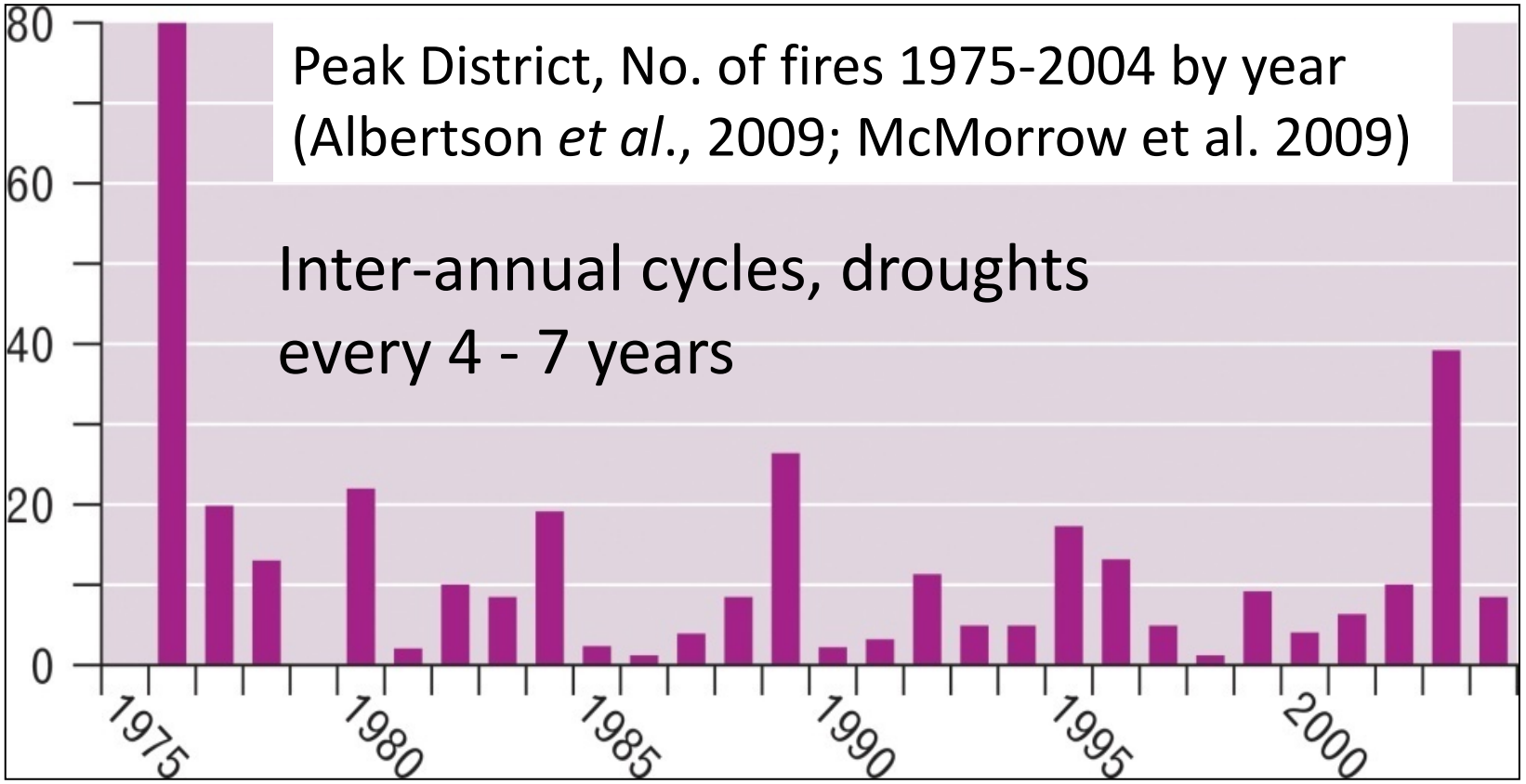
- 17% of all incidents attended by FRS; 4 x more incidents than flooding
- Expected increase with climate change
- Costly and dangerous to fight: costs Fire Service up to £55M pa. £1M for a large peat moorland fire

- Damage to **ecosystem services**: e.g. water discolouration, carbon loss, ecological restoration
- >£16M restoration in Peak District National Park

Peat moorland fire, Wainstalls near Halifax, April 2011

2. CHALLENGES FOR POLICY AND PRACTICE

Intra-annual variability

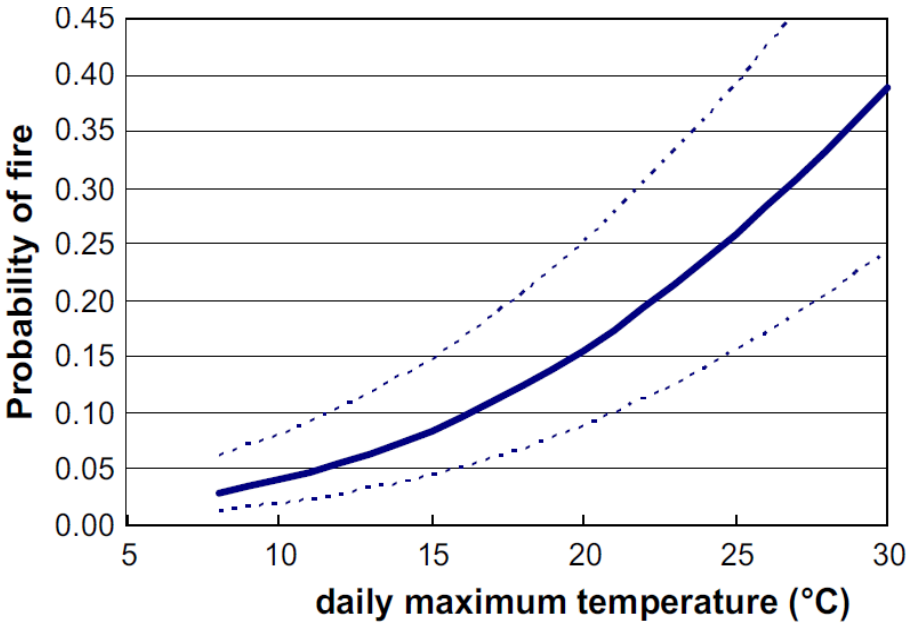


- UK wildfires double in droughts. Challenges public awareness and FRS resource resilience
- Wet years increase fuel load

Albertson *et al*. (2009)

WF risk management is growing; climate change

- Frequency & severity strongly related to weather;
  - Grassland fires doubled in drought yrs 1995 & 2003
  - In spring 2011, fires across all 4 home nations; 250 major events in 3 weeks in England alone
- WF risk is expected to increase with climate change (Albertson et al 2009, 2010). Rapid increase in probability of a fire with Temp.
  - 40% chance of a fire on a Spring Bank Holiday in the Peak District when max air T of 30˚C – including the people factor
  - Increased probability of resource-intensive, 'near miss' events → growing role in Incident Risk Management Plans



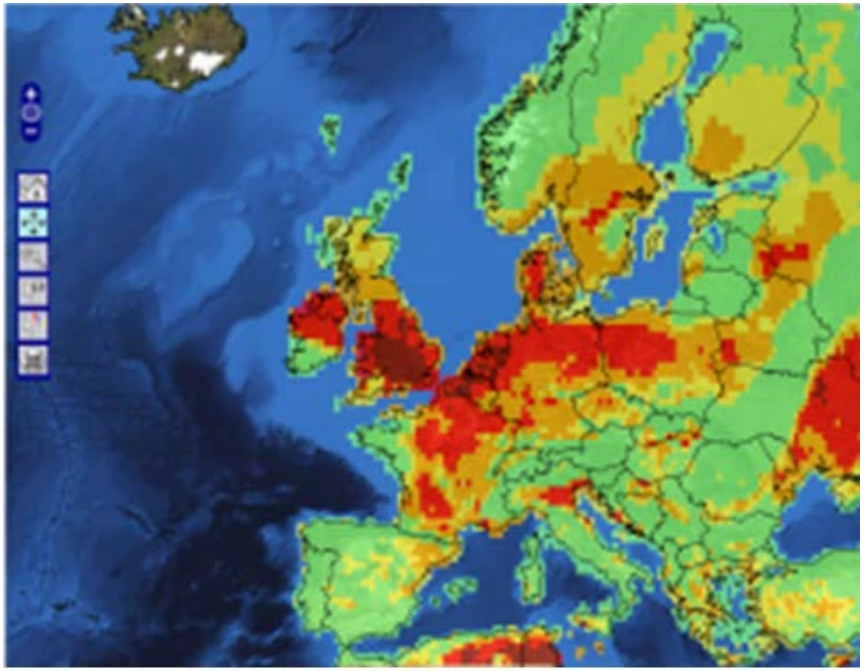
Limited fire danger rating system

Met Office England & Wales Fire Severity Index

- Canada Fire Weather Index , reduced to 0-5 scale. No sub-indices
- 10 km grid
- Not calibrated to land cover; limited empirical evidence of fire behaviour in UK vegetation types, especially heathland

http://www.metoffice.gov.uk/public/weather/fire-severity-index/#?tab=map&fcTime=1487592000&zoom=5&lon=-4.00&lat=55.74

European Forest Fire Information System (EFFIS)

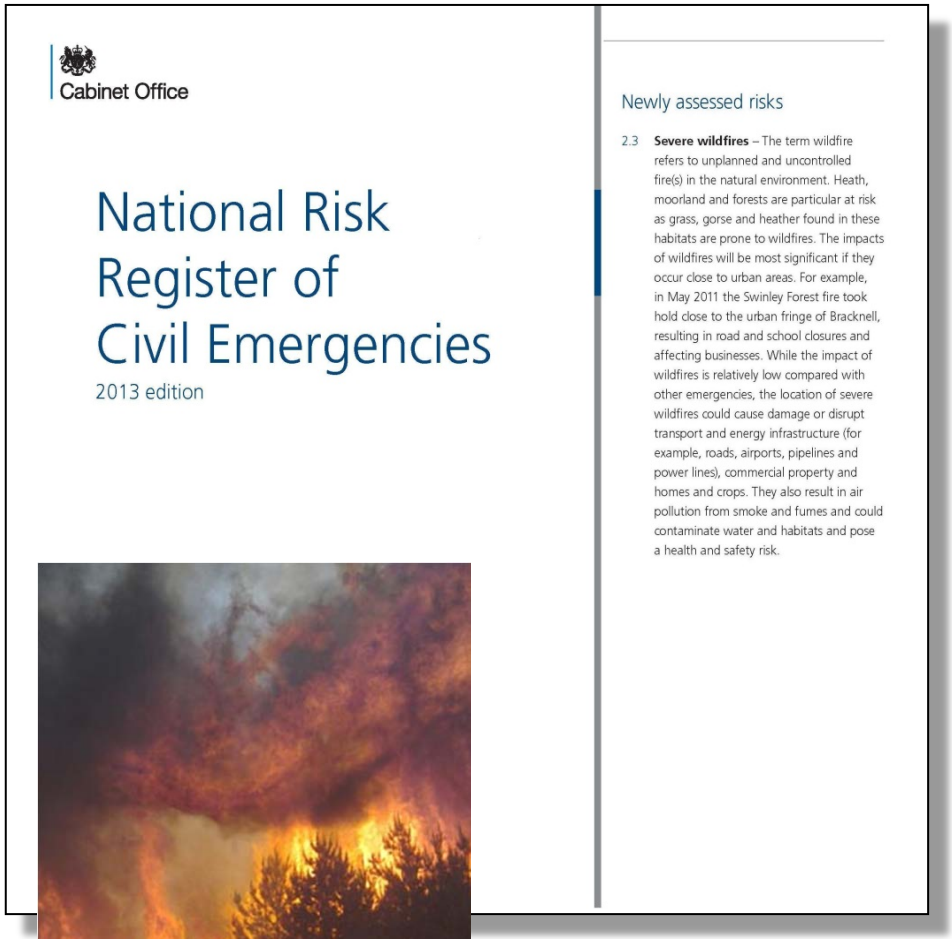


http://forest.jrc.ec.europa.eu/effis/

Poor awareness; power of a 'Black Swan' event

- Wildfire was a poorly recognised hazard until Spring 2011
- Mainly due to sporadic occurrence (unlike flooding), and poor evidence base until 2009
- Swinley Forest fire in the crowded rural-urban interface of southeast England raised political awareness
- Severe wildfire included for the first time in the National Risk Register of Civil Emergencies & rolled out to CRRs

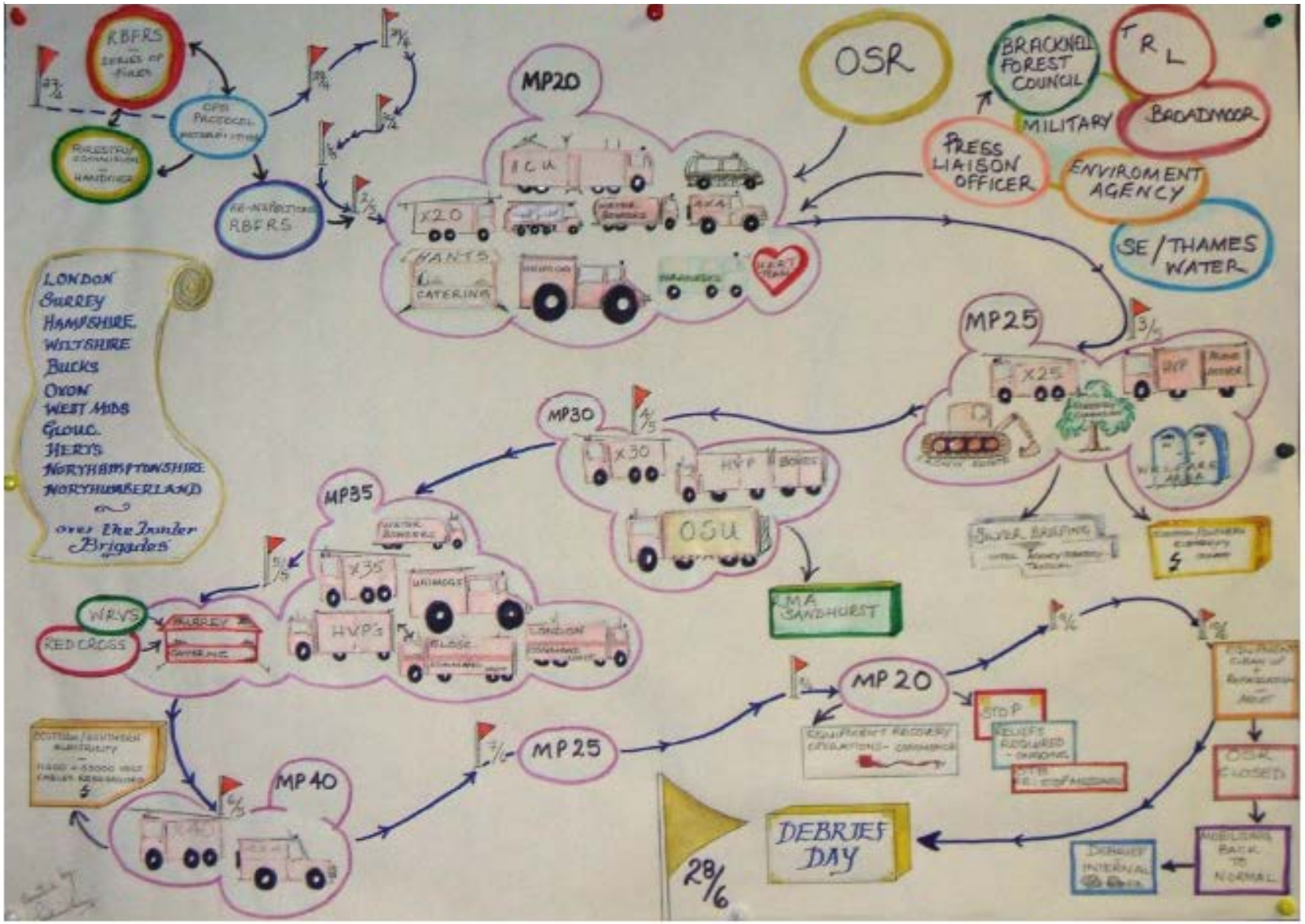
Gazzard *et al.* (2016)



https://www.gov.uk/government/collections/national-risk-register-of-civil-emergencies

A major fire: ‘Make pumps 40”

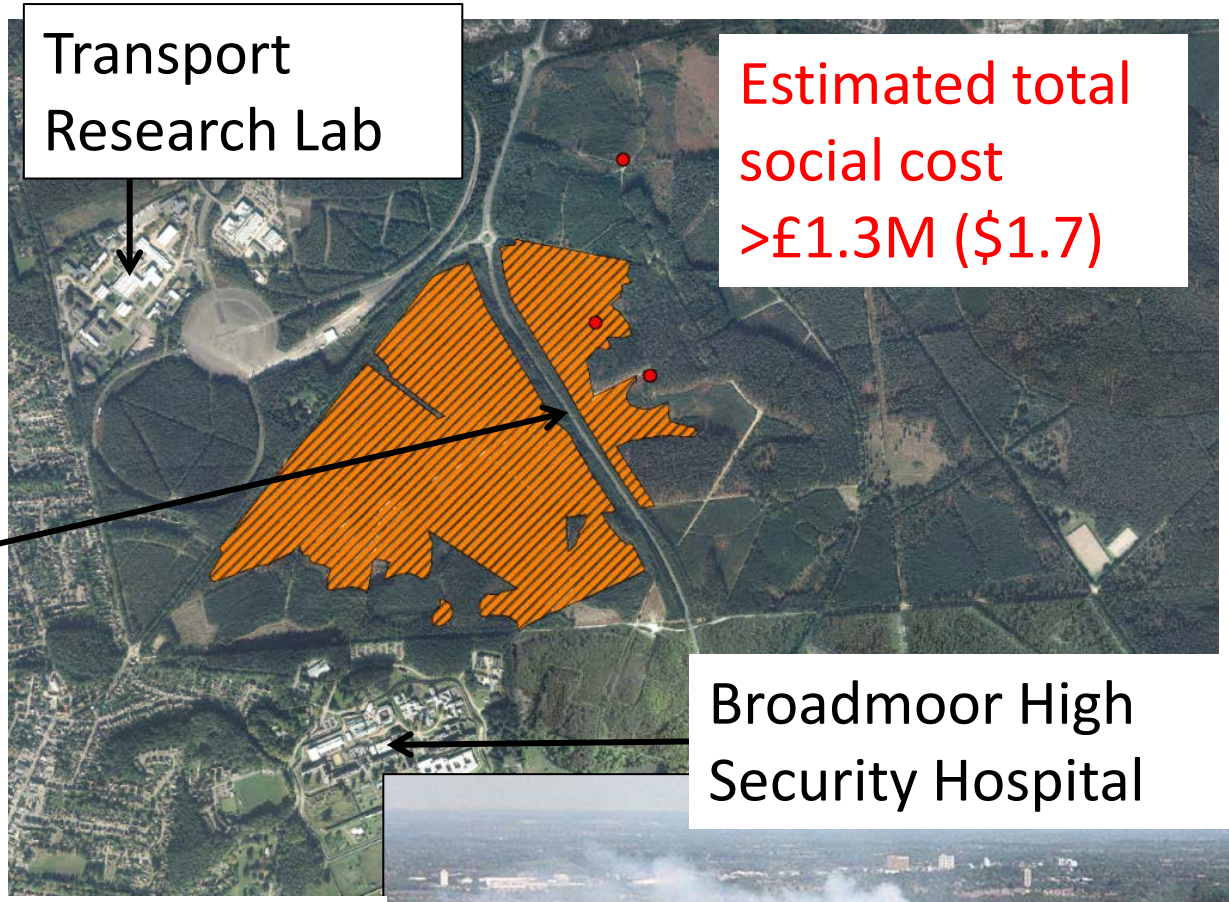
With thanks to Nick Oxborough, Royal Berkshire Fire and Rescue Service



Swinley Forest RUI Values at Risk

Surrounded by towns & critical national infrastructure

Road closures, ~£230K ($345K)



1220 people directly affected:
7 houses evacuated, 3 schools closed.
Smoke visible from Windsor Castle

Controversy over prescribed fire

- Forest cleared by fire from Neolithic
- Fire is integral to heather moorland ecosystem
- Rotational burn of heather patches every 15-25 yrs; habitat management for red grouse
- Winter burn season, peak in spring
- But very controversial on deep peat; equivocal evidence on water discolouration, loss of biodiversity
- Depends on burn severity and fire history (Davies *et al*., 2016a; 2016b)
- Research gaps ; does prescribed burn cause wildfire via escaped fires, or prevent it through fuel reduction?

Fragmented hazard chain

- Climate change + housing demand → growing need to manage fuel & ignition sources
- Wildfire is a cross-sector problem, but seen as a Fire Service one. Hazard chain management is fragmented:

DEFRA
Prevention
✓ People (Met Office FSI)
? Fuel management
✗ Improved ecosystem resilience

→

DCLG
Preparedness
Response

→

DEFRA
Restoration

- Requires interagency working, starting farther back in the hazard chain
- Local level fire groups fulfil this need

Gazzard *et al.* (2016)

Brexit?

- Uncertainty over future of agri-support for grazing & requirement for fire plans → fire like Port Hills?

More grazing would reduce fire risk in the Port Hills, argues **Derrick Moot**, who leads Lincoln University's dryland pastures research team.

Grazing stock lowers fire risk

The smell of smoke in the air over Christchurch was a vivid reminder of my own battle with fire on the Port Hills.

As a parent helper on camp at Living Springs I was called into action one balmy afternoon when a spark ignited grassland and the wind rapidly spread the flames up hill. Our wet sacks, shovels and beaters seemed futile but a change of wind and patch of native bush enabled us to control the fire after four, physically demanding hours.

The locals thanked God for our let off and I smiled gratefully at the green vegetation barrier and dying easterly wind that intervened.

Fire is an ever present danger in dry east coast regions of New Zealand but its impact has been exaggerated by recent changes in land use on the Port Hills.

Decisions to remove stock from some areas and reduced numbers in others means there is a ready and growing fuel source that makes ongoing summer fires inevitable.

The tall oat grass and clumps of cocksfoot amongst the tussocks, that combine to give the hills their characteristic tawny hue, are symptoms of lax grazing and poor pasture management. On commercial farms throughout the east coast, sheep and cattle are right now in mobs rotating around paddocks to clean up this excess feed and reduce the fire risk after a wet spring.

For many reasons this is no longer happening on the Port Hills, or for that matter on some high country areas recently retired under tenure review.

The few stock left on the Port Hills can now be selective about

The tall oat grass and clumps of cocksfoot among the tussocks, which combine to give the hills their characteristic tawny hue, are symptoms of lax grazing and poor pasture management.

The Press, 20 Feb 2017

- Future of EU environmental protection; e.g. Water Framework Directive for catchment-based management of water quality – water companies currently big players in managing peat fires

Need for improved evidence base

- Pre-2009, incomplete & inconsistent recording of vegetation fires by >50 regional FRS
- Only ‘primary fires’ recorded, just a sample of smaller fires. Address-based call-out location, not fire ground.
- Since April 2009, all vegetation fires recorded in nationally standard format
- 6-figure geo-referenced ideally to fire ground
- Potential for GIS analysis but not being done. Non-spatial national report after 6 months
- Was no formal protocol to identify the more significant ‘wildfires’

Improving management of UK wildfire through knowledge exchange

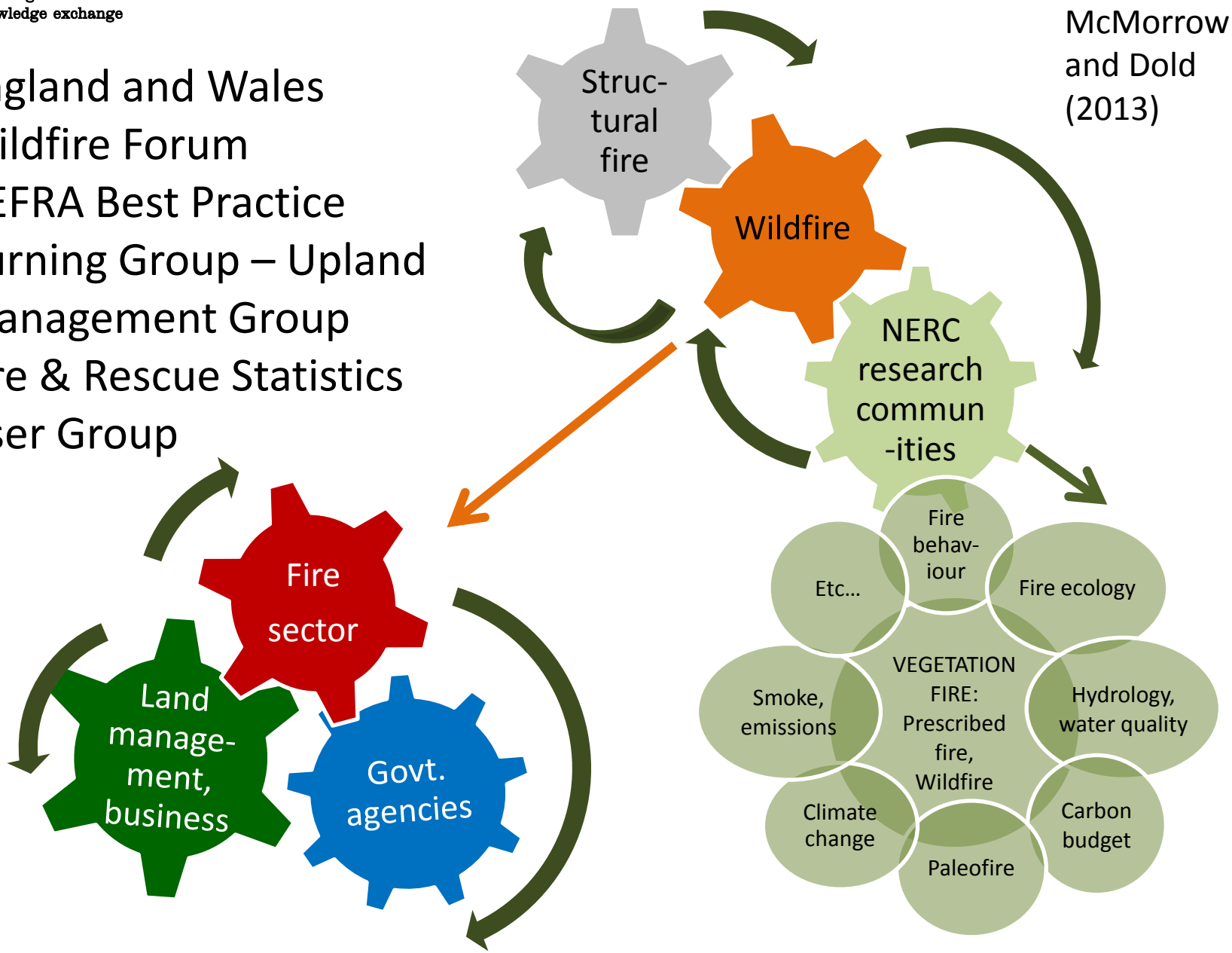
www.kfwf.org.uk

3. KNOWLEDGE FOR WILDFIRE PROJECT (KfWf)

KfWf
Improving management of UK wildfire through knowledge exchange

Who we work with

- England and Wales Wildfire Forum
- DEFRA Best Practice Burning Group – Upland Management Group
- Fire & Rescue Statistics User Group



McMorrow and Dold (2013)

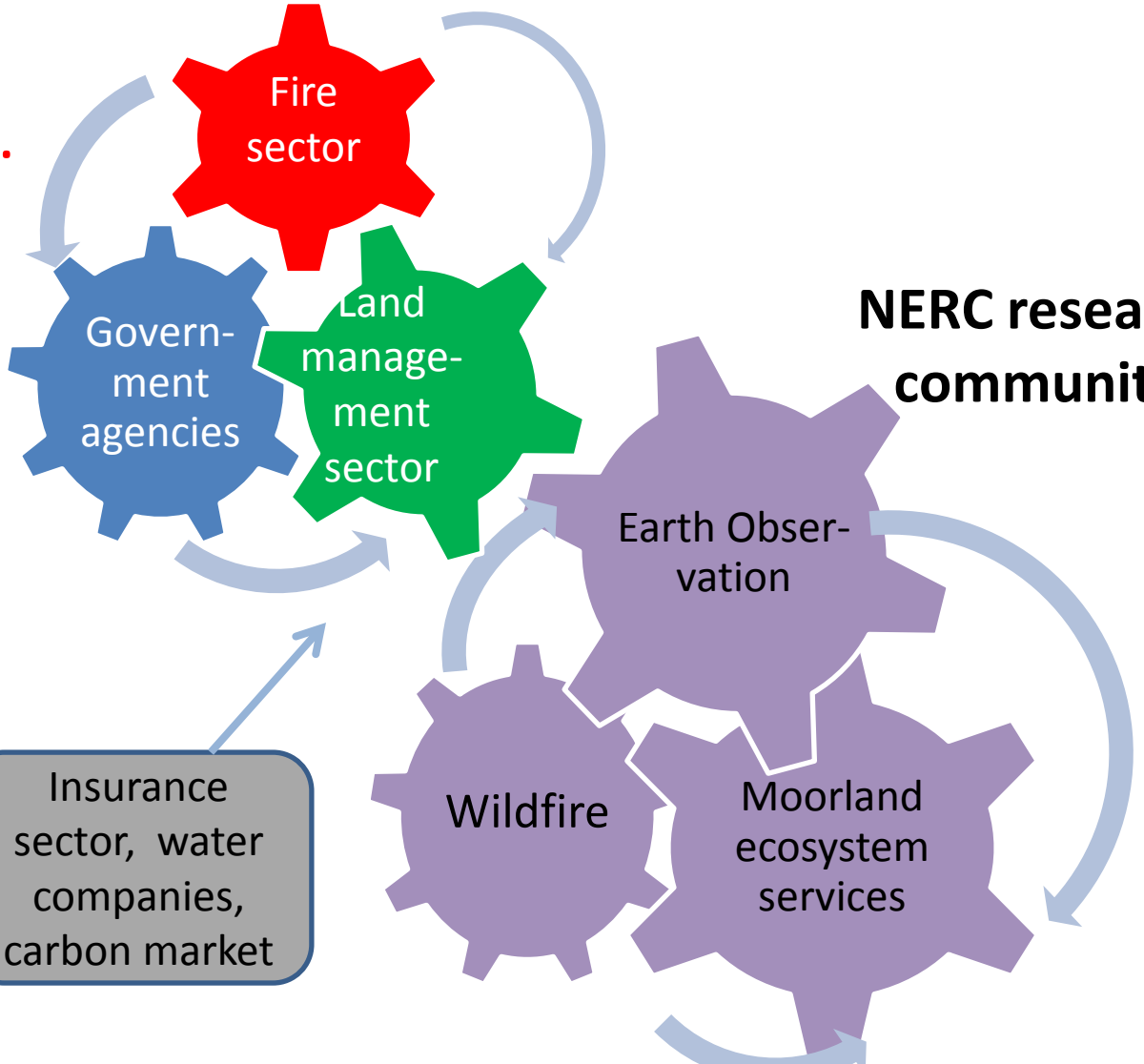
KfWf: Joining up key stakeholder groups

England and Wales Wildfire Forum (EWWF)

Regional Fire & Rescue Services
Chief Fire Officers Assoc.
Fire Brigades Union

Natural England,
Met Office,
Forestry Commission
Cabinet Office
DCLG
MOD
Highways Agency
etc

The Heather Trust
Moorland Association
CONFOR, etc



NERC research communities

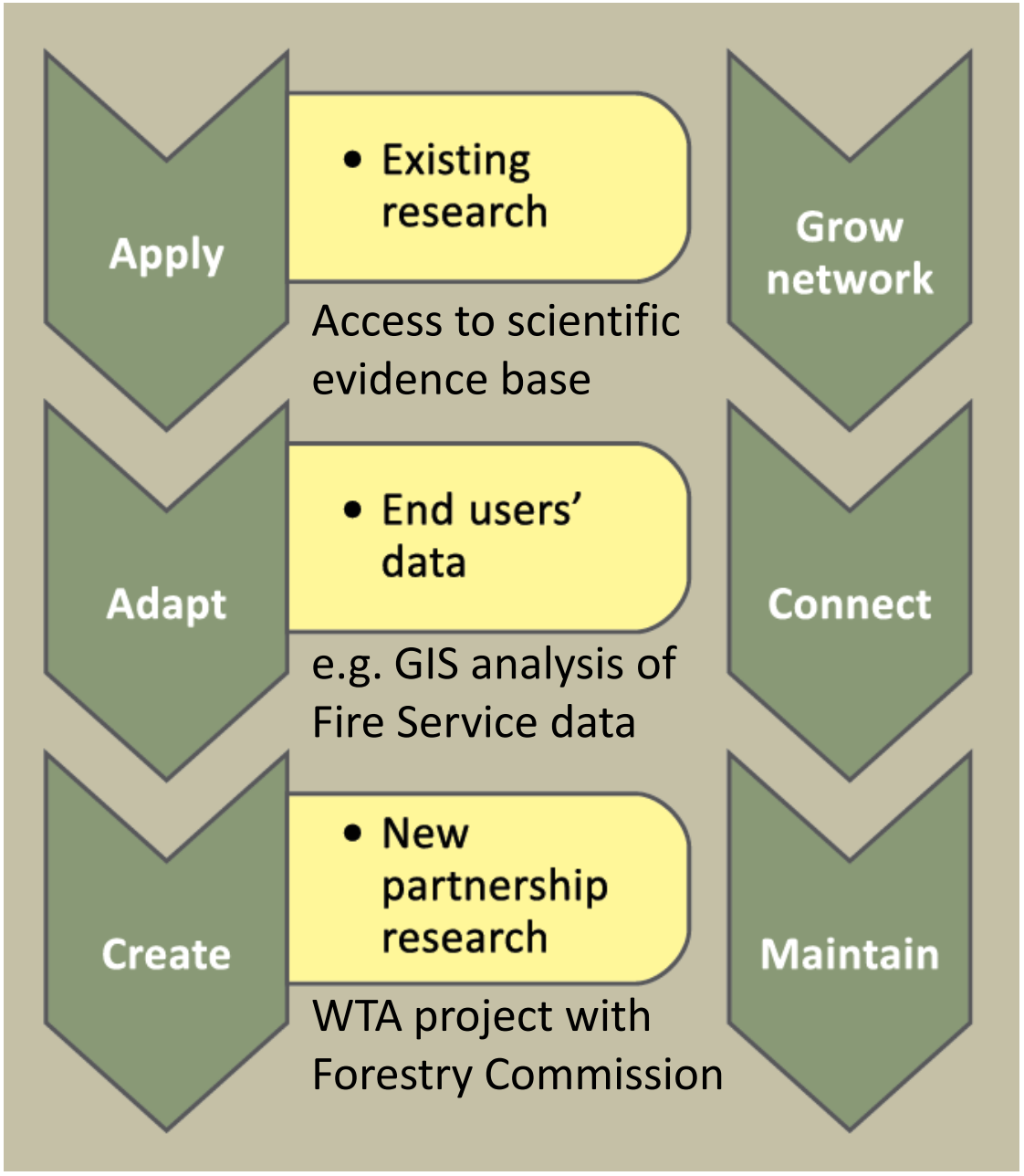
KfWf
Improving management of UK wildfire through knowledge exchange

Activities & types of knowledge

Know-why
learning by studying

Know-what
learning by using

Know-how
learning by doing



Know-who

Networking:

- wildfire@manchester events
- Conference sessions
- England & Wales Wildfire Forum, etc.
- Website www.Kfwf.org.uk
- Twitter KfWf_Manchester

(i) Defining ‘wildfire’ from IRS national fire statistics

(ii) Wildfire Threat Analysis for the forest-urban interface in SE England

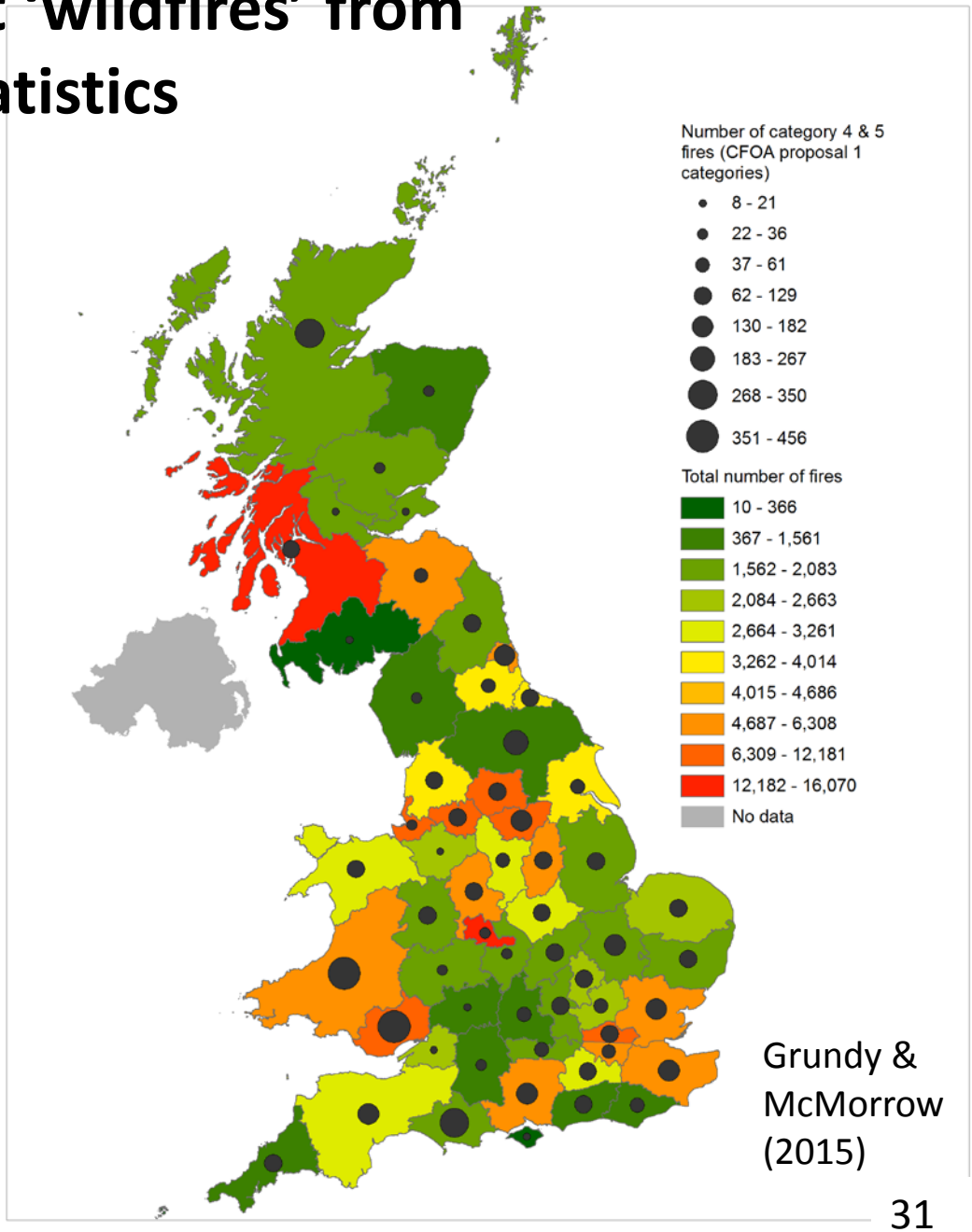
(iii) [Wildfire in Community Risk Registers]

(iv) Remote sensing of wildfires

4. IMPROVING THE EVIDENCE BASE WITH GEOSPATIAL TECHNIQUES

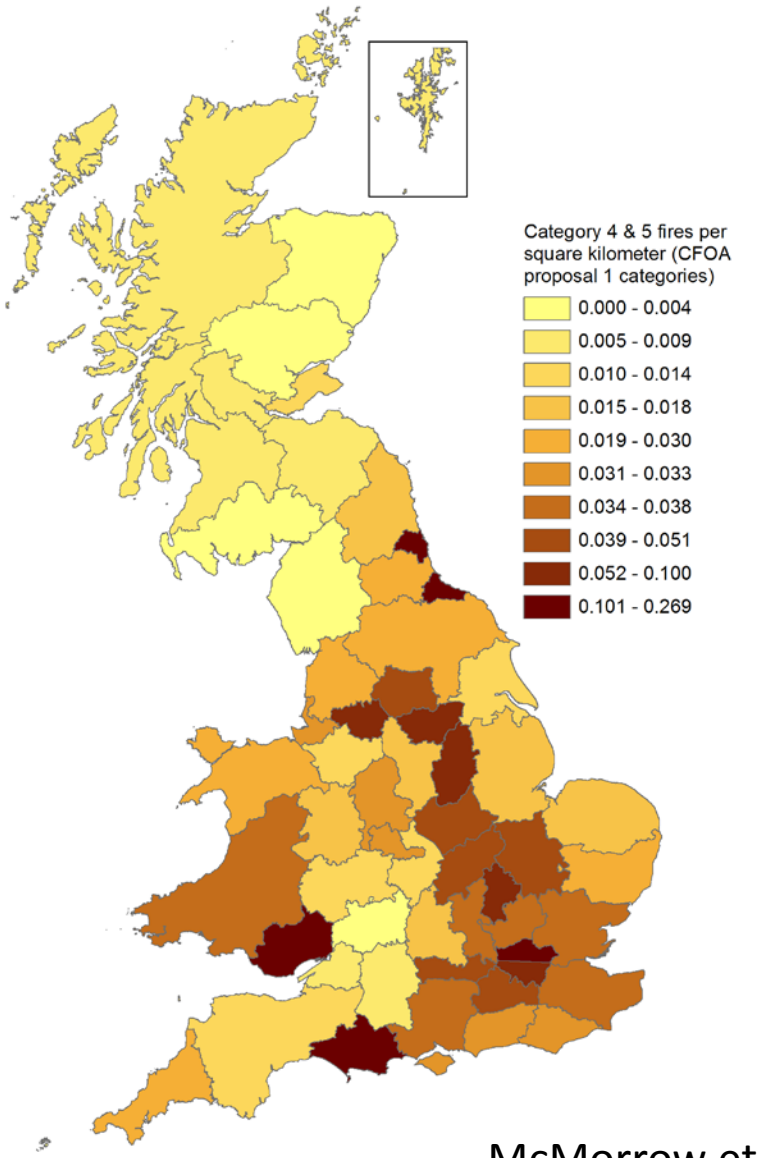
(ii) Identifying significant 'wildfires' from national fire statistics

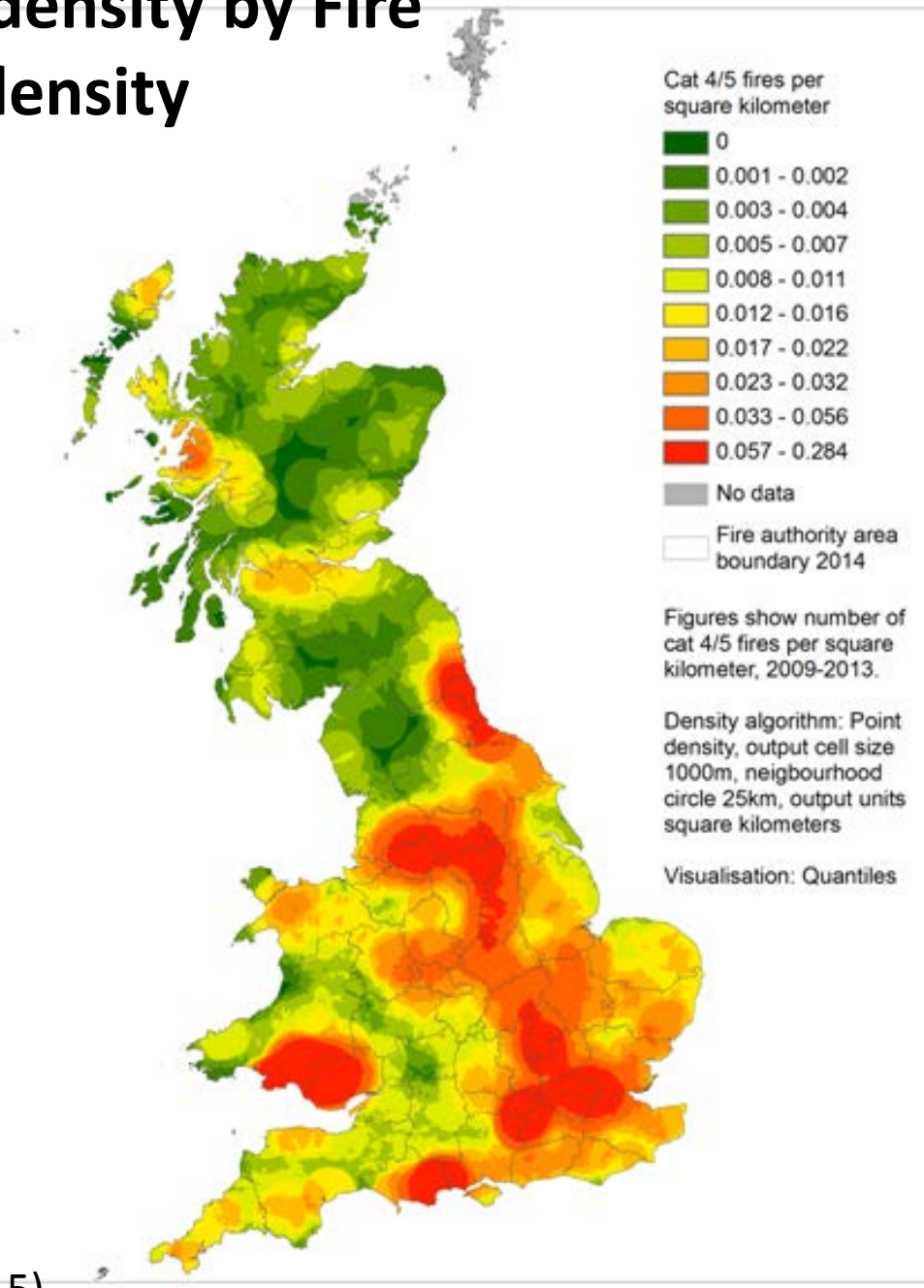
- Shading shows number of <u>all</u> vegetation fires by Fire Authority
- Circles show significant <u>wildfires</u> using Scottish manual definition (CFOA proposal category 4 & 5):
  - ≥ 1 ha
  - Or ≥ 6 hours callout
  - Or ≥ 4 vehicles
- Future access to critical data fields and record-level data may be restricted due to data protection



Grundy & McMorrow (2015)

Need for record-level data: density by Fire Authority vs point density





McMorrow et al. (2015)

(ii) Wildfire Threat Analysis scoping study

- **Need**: Forestry Commission England need to manage wildfire threat to forest assets and surrounding communities
- **Aim**: to test the applicability of Wildfire Threat Analysis (WTA) framework
- WTA sees wildfire threat as a combination of three GIS modules, each made up of GIS layers

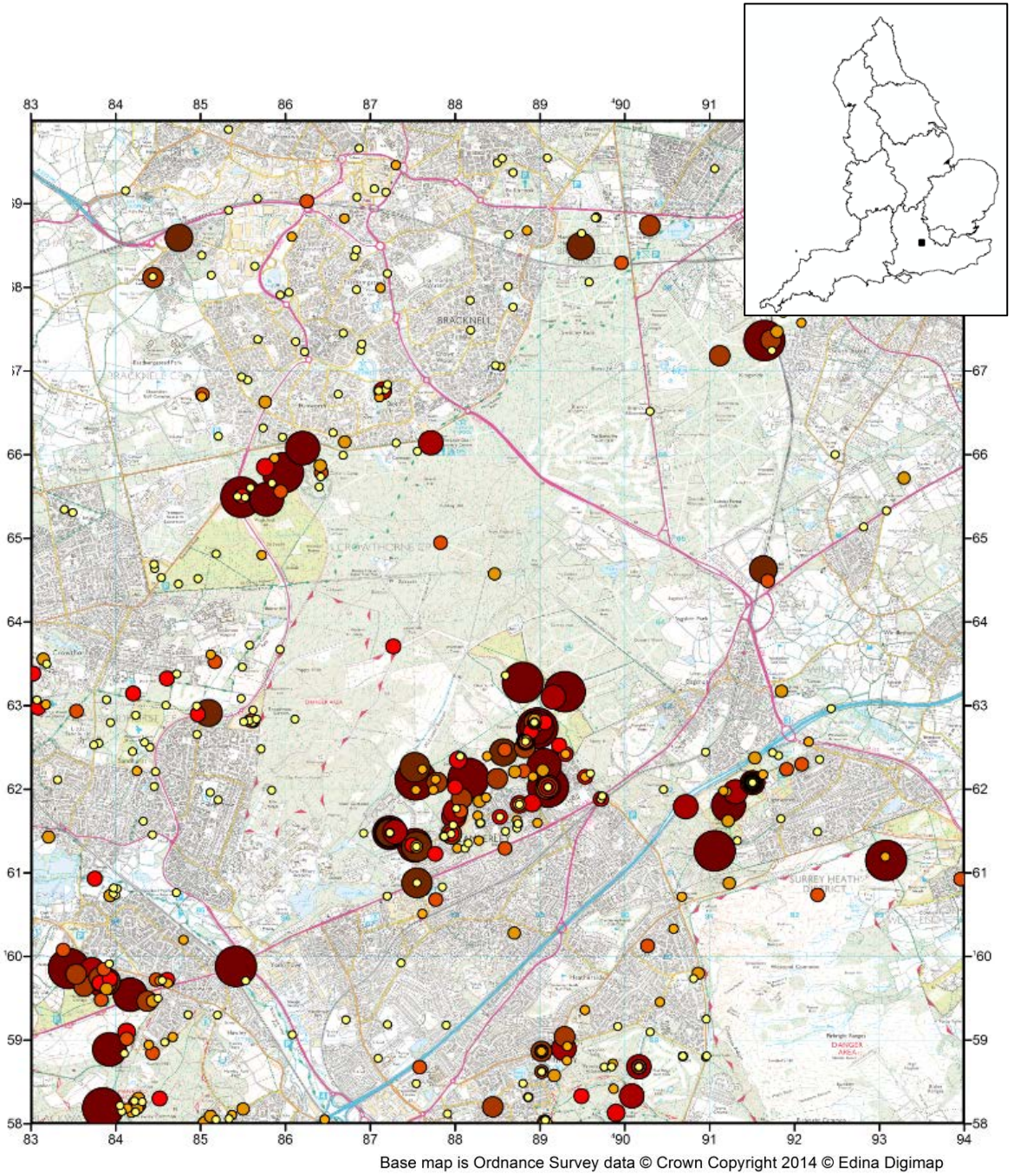
Questions addressed:

1. How well does WTA fit with existing UK risk frameworks?
2. Can WTA can be translated into practice as a pilot GIS tool for FCE, considering data availability and sources of uncertainty?

Case study area

964 attended fires in 4 yrs, 2009-2013; Fire Services' Incident Recording System (IRS)

0 1 2 3 4 Kilometers



Base map is Ordnance Survey data © Crown Copyright 2014 © Edina Digimap

WTA Methods

For each module, multi-criteria evaluation was used to combine GIS layers (criteria), guided by expert knowledge from 2 workshops and meetings:

1st workshop

2nd workshop

Meetings

1. Select ↓

Which GIS layers (criteria, factors) to include

Sourcing data (90+ layers); understanding data limitations. Developed a data catalogue.

2. Score ↓

Capture how layers vary spatially

e.g. risk of ignition score of each land cover

3. Weight ↓

Relative importance of factors

Expert knowledge to weight layers before combining

4. Map ↓

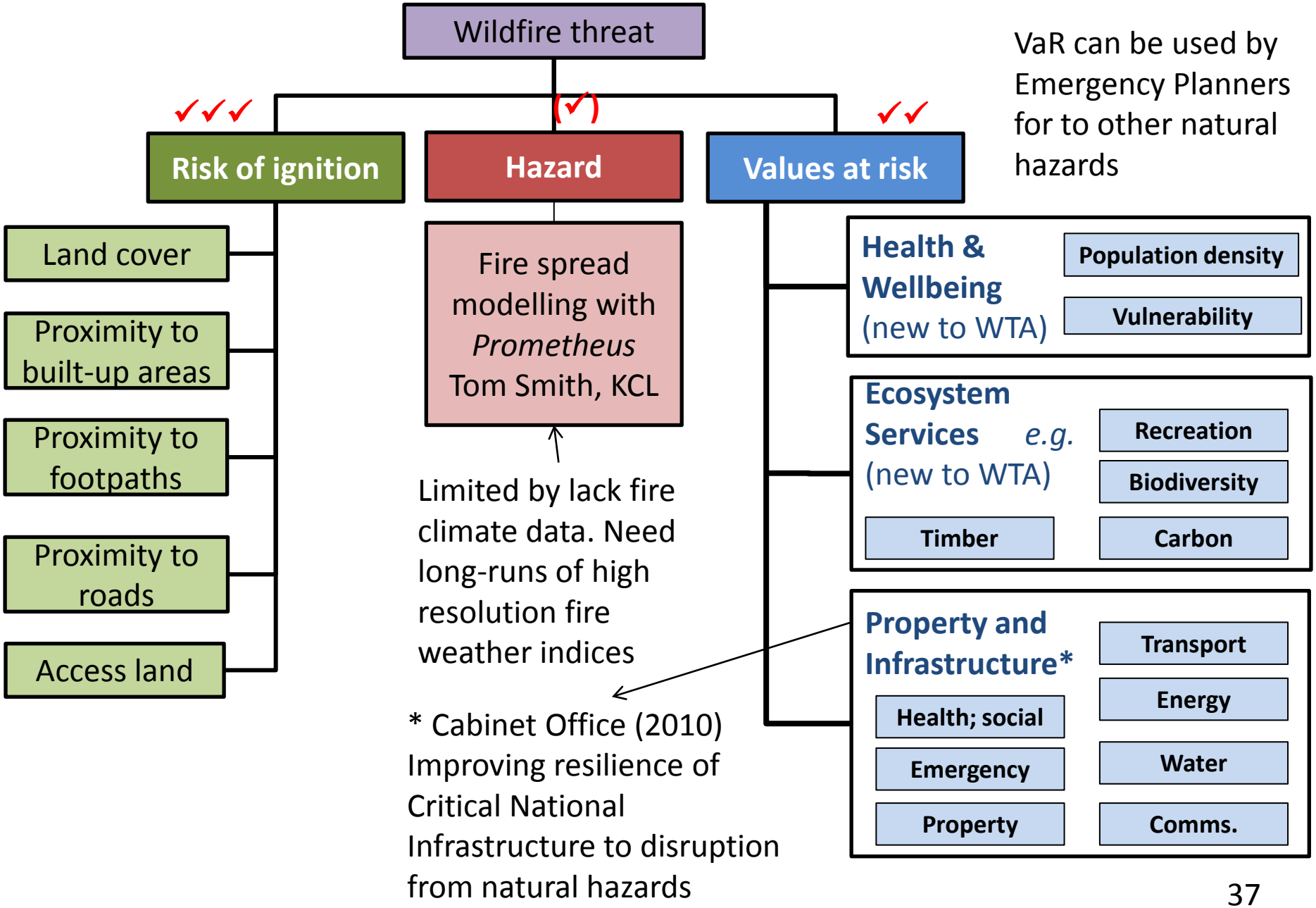
How to represent results

Number of classes, etc

5. Evaluate

Accuracy of the results

Modified Wildfire Threat Framework



Outputs: Risk of Ignition map to target prevention

Weighting

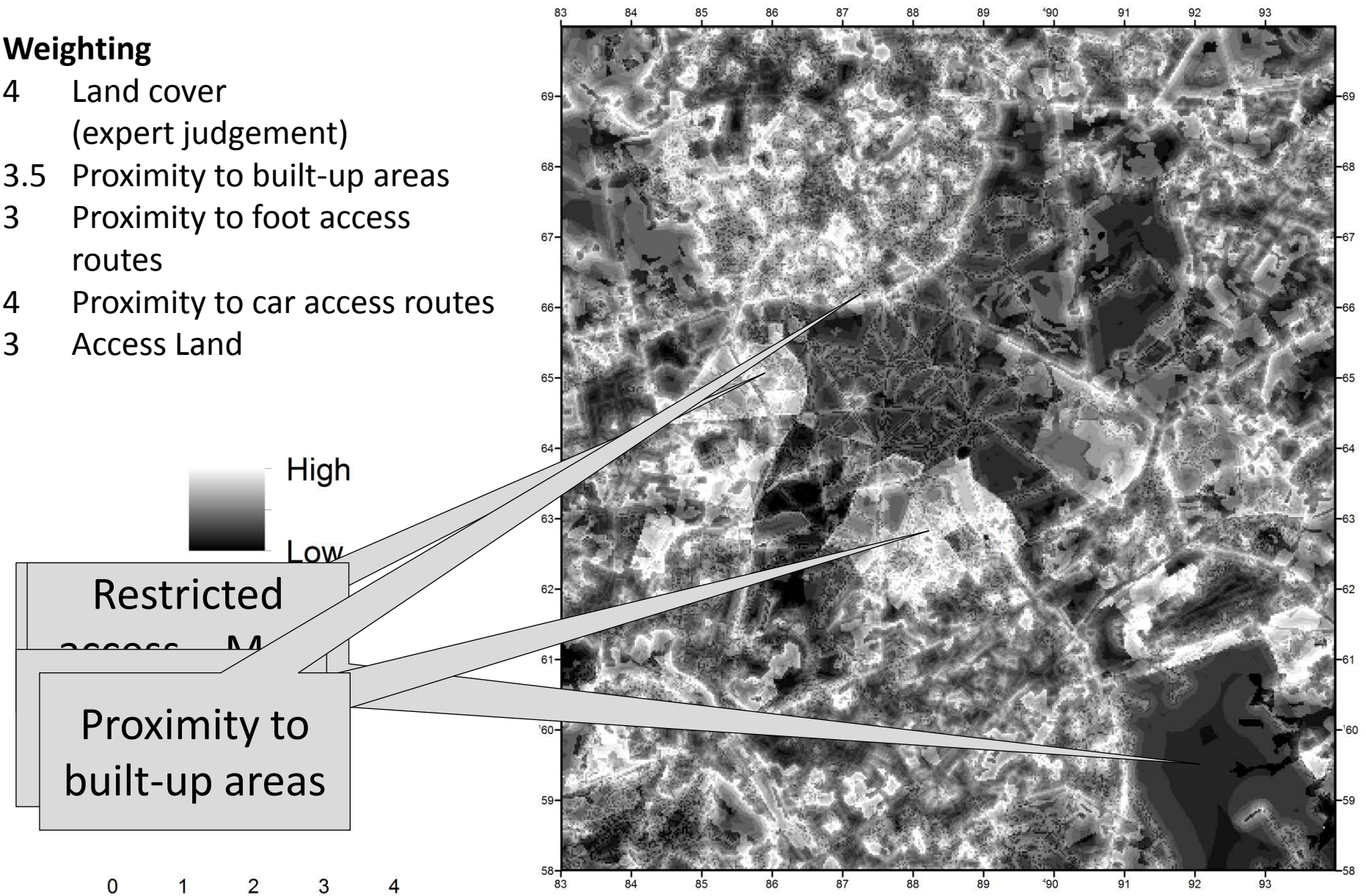
4 Land cover (expert judgement)

3.5 Proximity to built-up areas

3 Proximity to foot access routes

4 Proximity to car access routes

3 Access Land



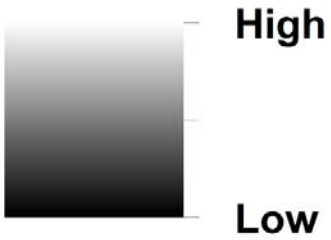
Values at Risk map to target forest management and Firewise communities

Weighting

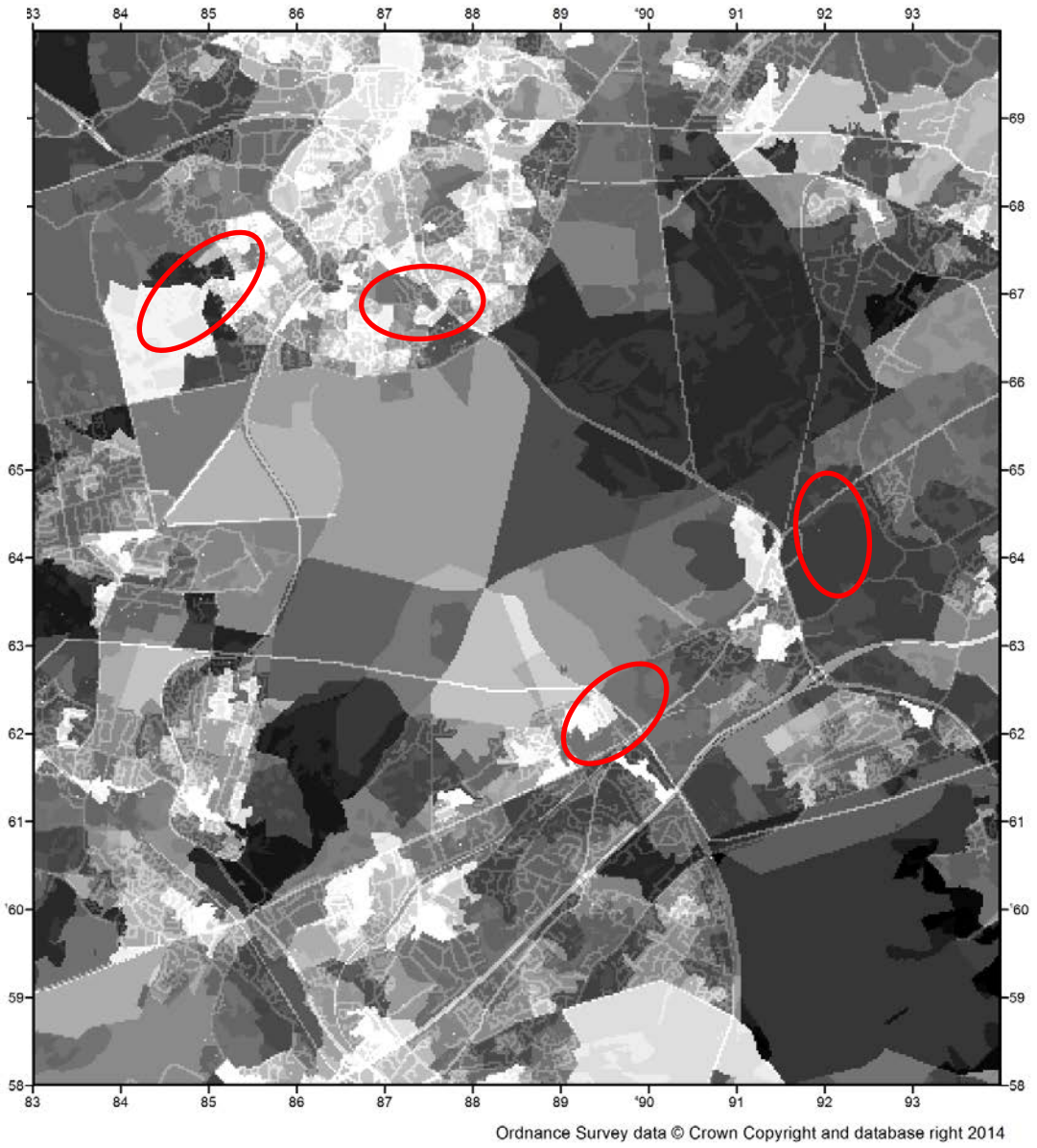
5 Health & well-being

3 Property & infrastructure

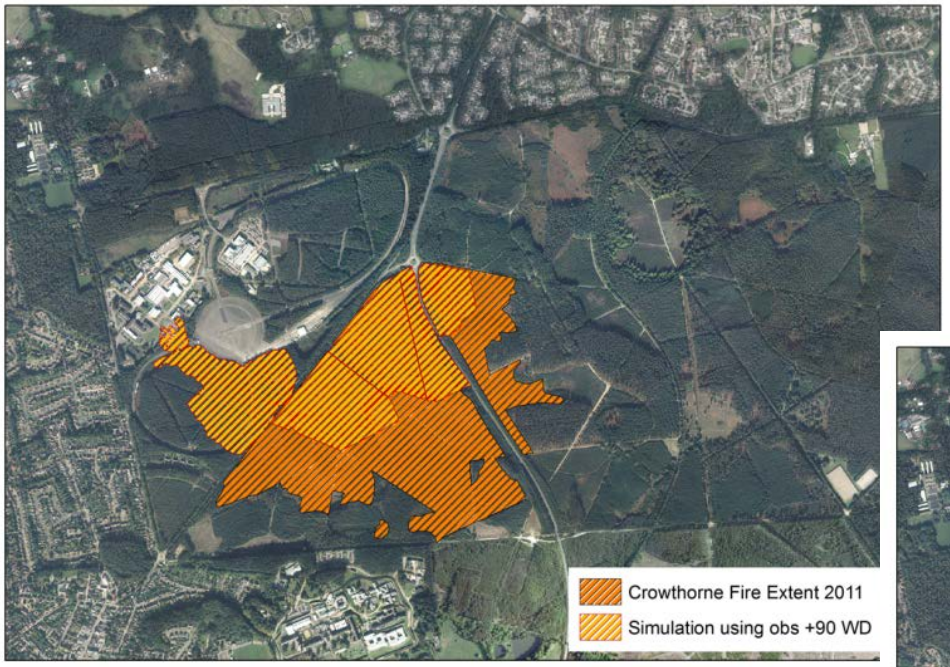
1 Ecosystems services



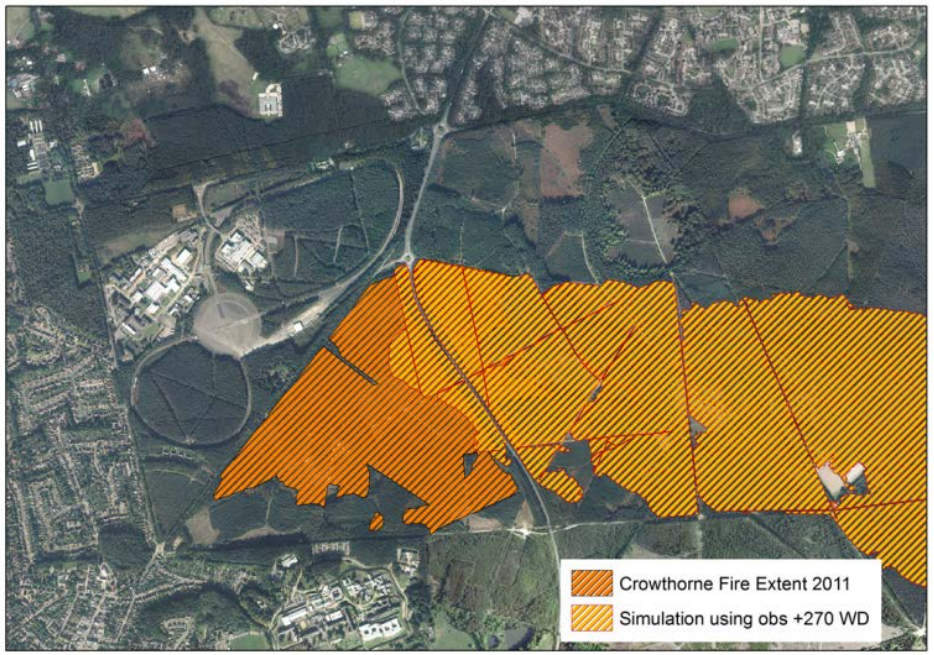
Overlay actual or simulated fire perimeter to show values actually at risk



HAZARD: modelled fire footprints



Prometheus fire spread modelling of 2011 Swinley Forest fre



Wind change by 90° from NE to SE'ly

Wind shift by 270° to W'ly

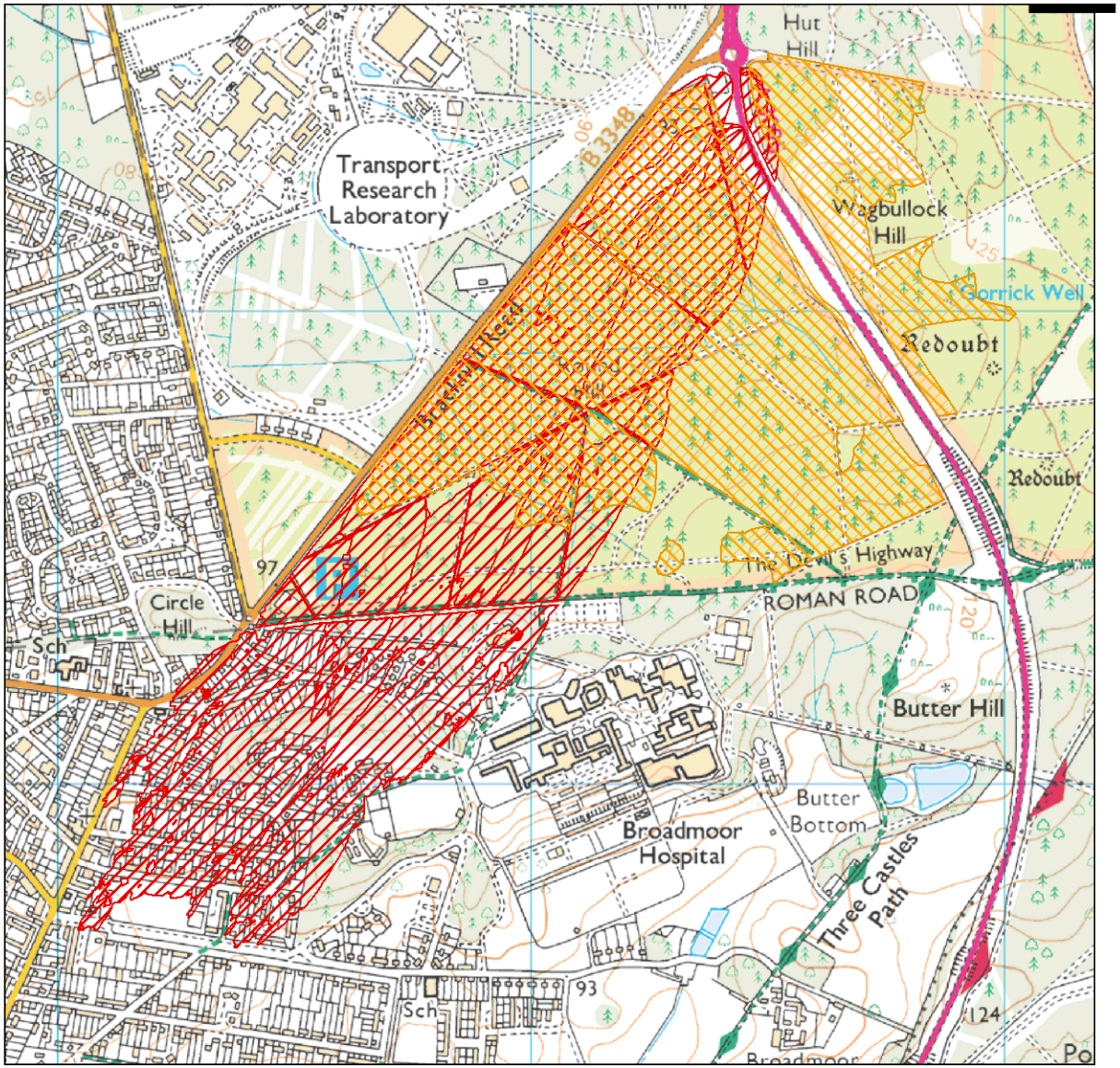
thomas.smith@kcl.ac.uk

Overlay on VaR → avoided costs

The actual Crowthorne fire extent

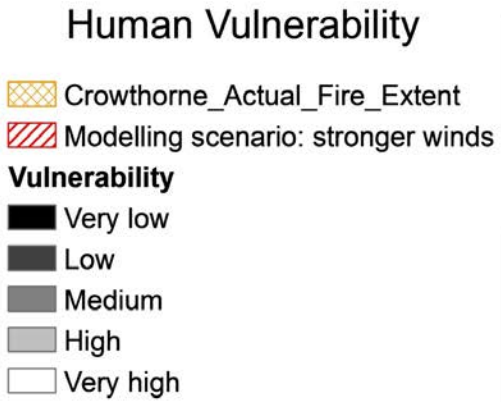
Modelling scenario: stronger winds

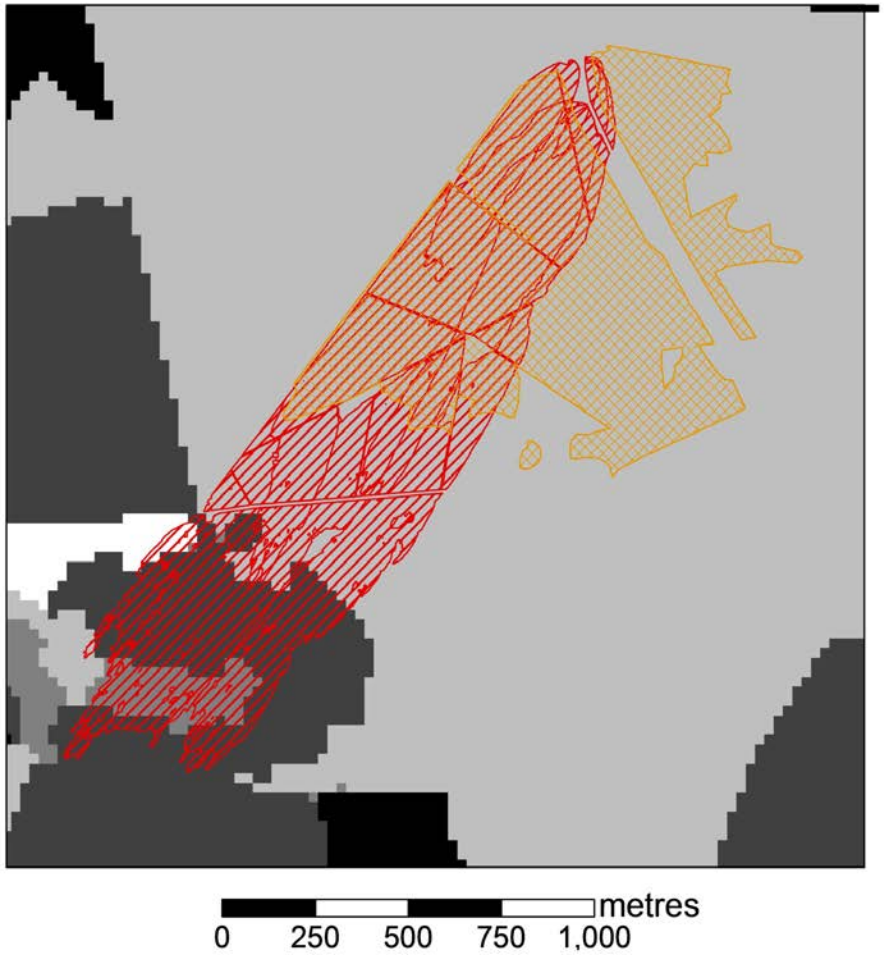
3.4 km more roads would have been directly within fire footprint (excludes smoke plume)

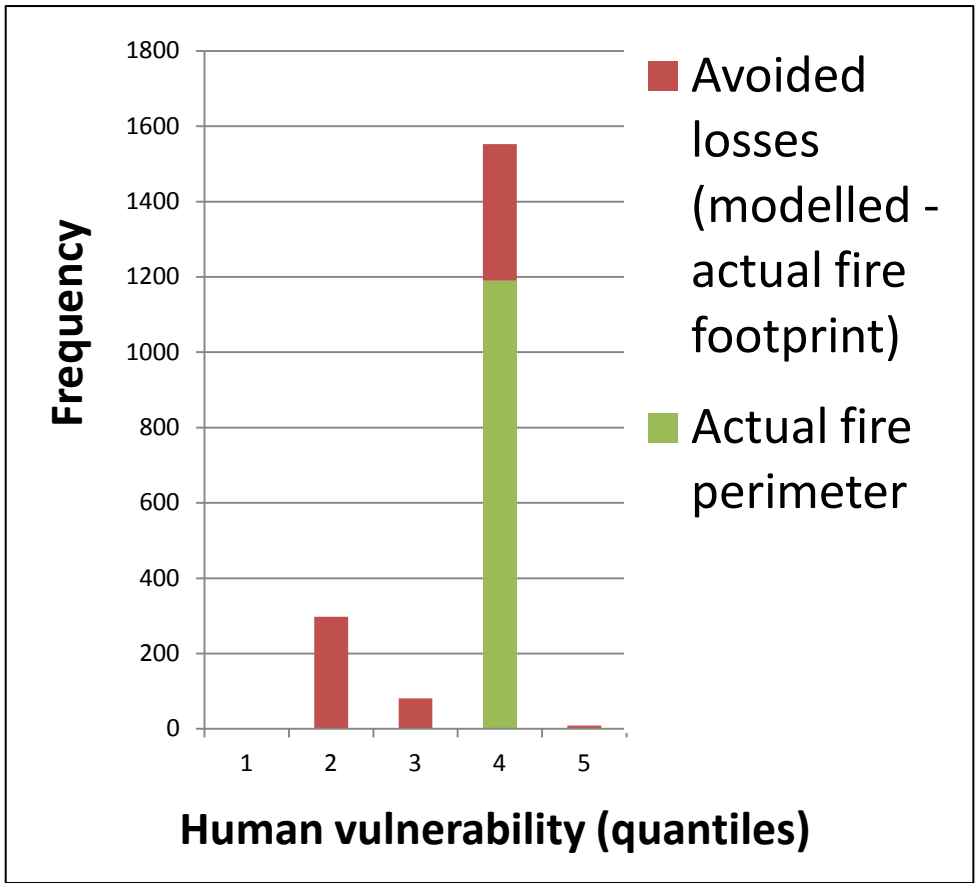


0 250 500 750 1,000 metres

Avoided costs



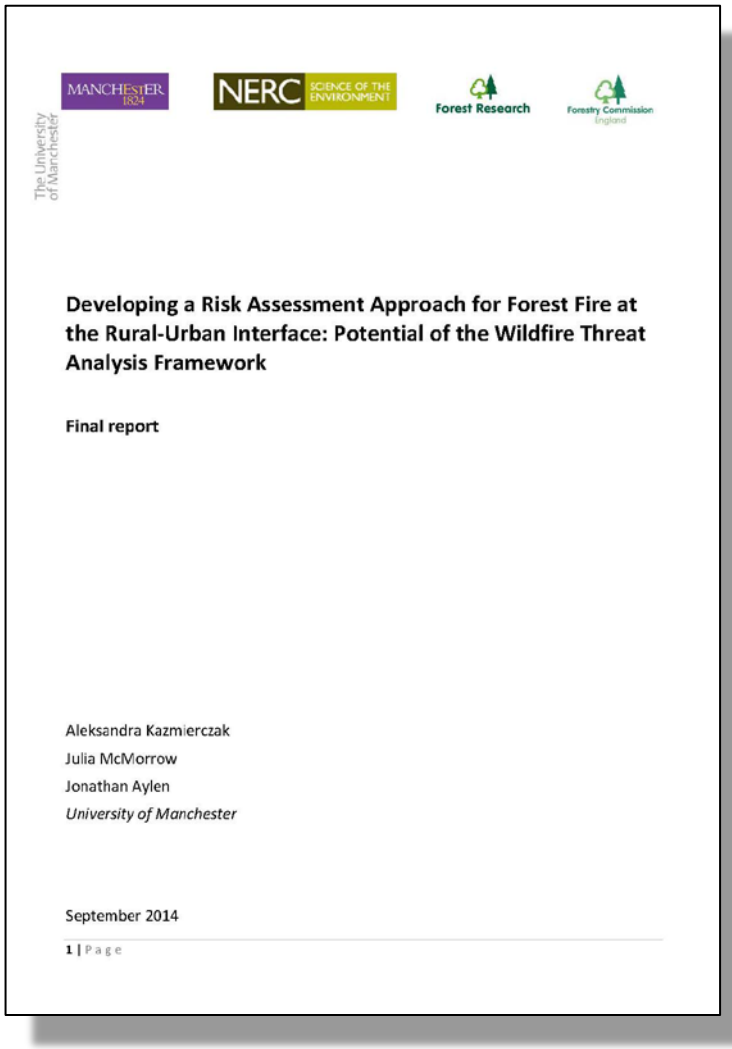




63% larger footprint.
31% more in high human vulnerability class

Successes

- **Buy-in** from 11 organisations (22 person-days) including FC, Natural England, MoD, Emergency Planners, FRS: *"useful for a commander in the case of an incident to decide where to allocate resources"*
- **Data catalogue** of >90 layers, mostly publically available
- **Customised for UK case study**: added ecosystem services and social vulnerability
- **'What if' scenarios**: update to post-2011 fire – how is threat changed by fire itself, fuel management, new housing/ footpath/Country Park, etc?
- Valuable as a **discussion support tool;** for processual, co-produced mapping



The University of Manchester

Developing a Risk Assessment Approach for Forest Fire at the Rural-Urban Interface: Potential of the Wildfire Threat Analysis Framework

Final report

Aleksandra Kazmierczak
Julia McMorrow
Jonathan Aylen
University of Manchester

September 2014

1 | Page

79 pp report available on request. 4pp summary from www.kfwf.org.uk (McMorrow *et al*., 2014b)

Issues & next steps

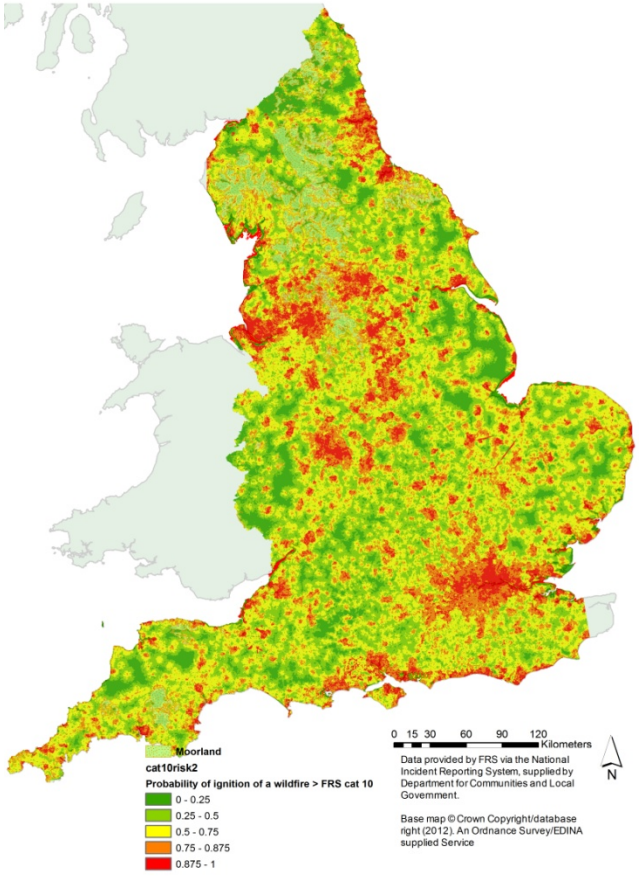
- **Data collation effort** from multiple sources; mostly national datasets, but local data availability and quality varies. Update maps every 5 yrs. Re-use for/from other hazard assessments.
- **Importance of local stakeholder knowledge for VaR:** *"The [VaR] maps are difficult to understand without having gone through the stages"*
- **Stakeholders views vary** on weighting. Try a more objective method; logistic regression based on IRS with 1 ha cells
- **IRS locational accuracy** Need nationally-consistent, agreed point on fire ground, ideally estimated ignition point. Preferably fire perimeters
- **No legislative framework yet** to drive action on fire management

Next steps: refine and test transferability

- Some issues with IRS fire point data , but potential for more objective statistical modelling of RoI at cells size >1 ha
- Develop hazard module, *e.g*. incorporate fire weather data from Met Office project.
- Extend values at risk, especially other ecosystem services layers
- NZ's WTA was national scale, ours was local; need to test transferability to regional and national scales and to other areas of UK

Recommend nested WTA: national (2km + landscape-scale >1ha)

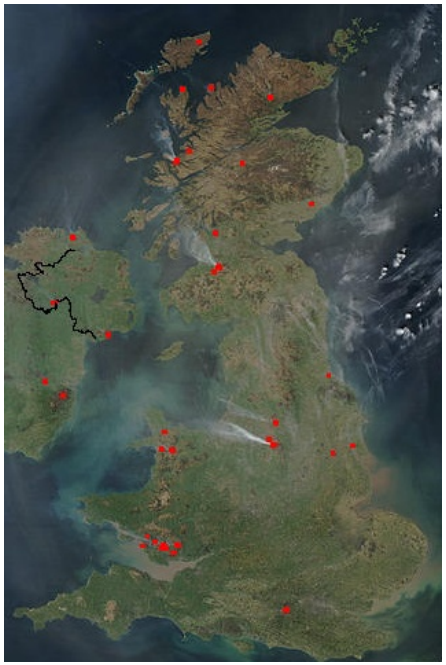
1. National RoI module; IRS-based logistic regression
2. Calibrate Met Office's 2km Fire Severity probabilistic Fire Weather sub-indices against Fuel Moisture Content → seasonal 'ignitability'
3. National 'worst case' wildfire hazard: module: Met Office FSI sub-indices + DEM slope, aspect + a fuel map from LCM2007/ National Forest Inventory
4. Combine national RoI + Hazard → target critical areas for a full landscape scale WTA, including VaR.



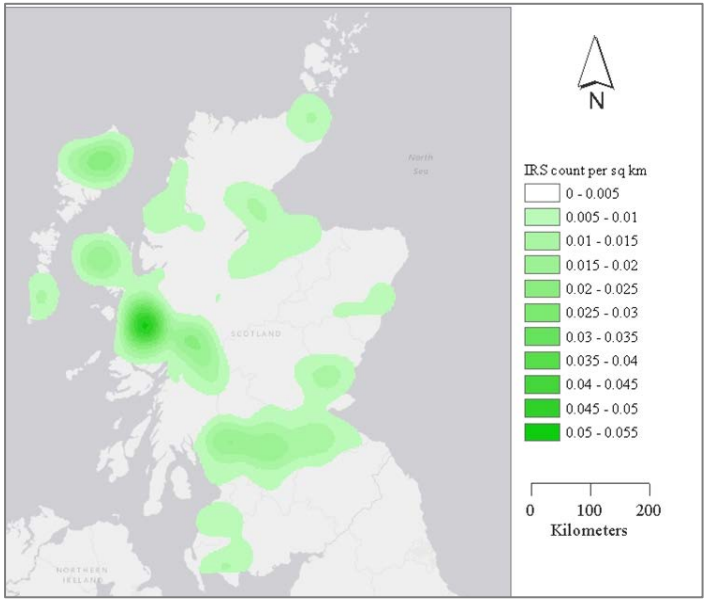
McMorrow *et al.* (2014a, b)

(iv) Remote sensing: MODIS *vs* IRS for fire regime

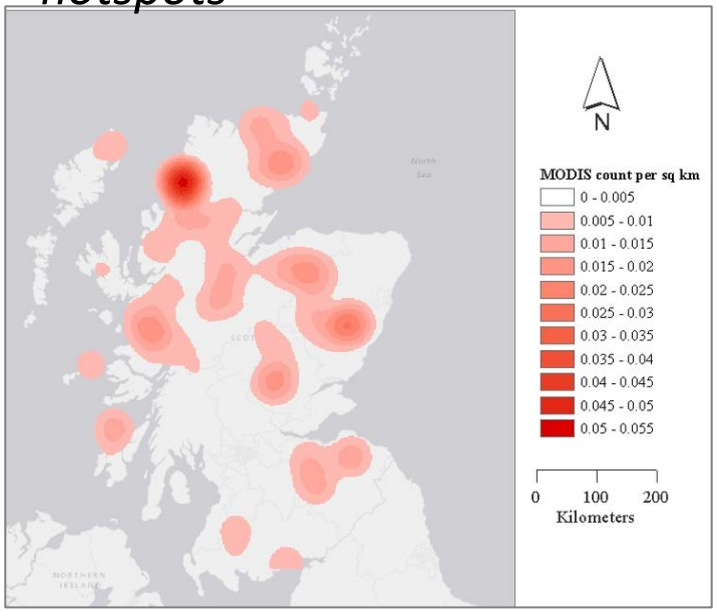
- Vegetation fires detected MODIS compared against IRS fires
- Only 47% of MODIS vegetation fire hotspots (screened by land cover) match IRS fires due to cloud, size, short duration



IRS wildfires, 2009-10 – 2012/13

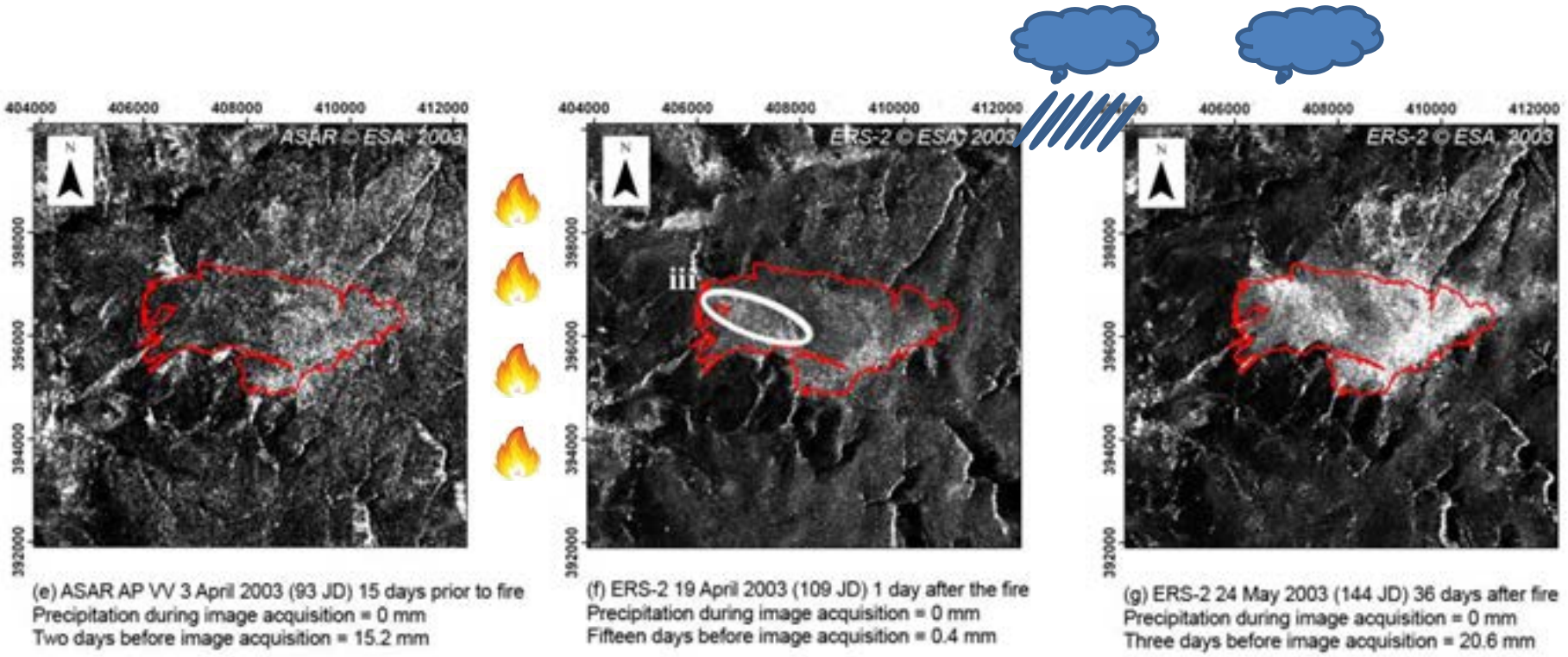


MODIS screened hotspots



Critchley & McMorrow (2015) http://www.kfwf.org.uk/_assets/documents/wildfire2015/Wildfire2015_Critchley_McMorrow_Wildfire2015_Poster.pdf

RADAR images detect burn scars through cloud and at night



(e) ASAR AP VV 3 April 2003 (93 JD) 15 days prior to fire
Precipitation during image acquisition = 0 mm
Two days before image acquisition = 15.2 mm

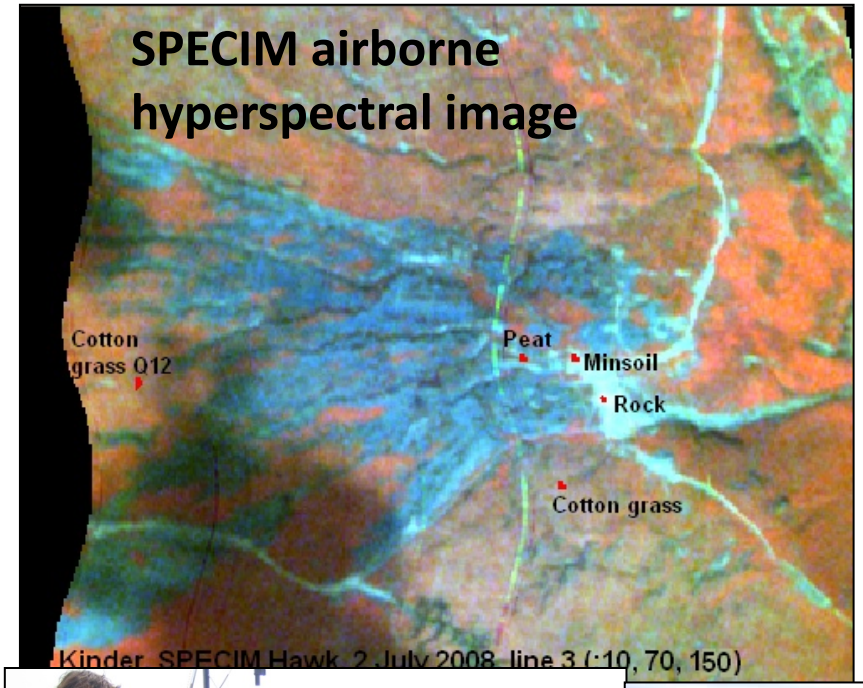
(f) ERS-2 19 April 2003 (109 JD) 1 day after the fire
Precipitation during image acquisition = 0 mm
Fifteen days before image acquisition = 0.4 mm

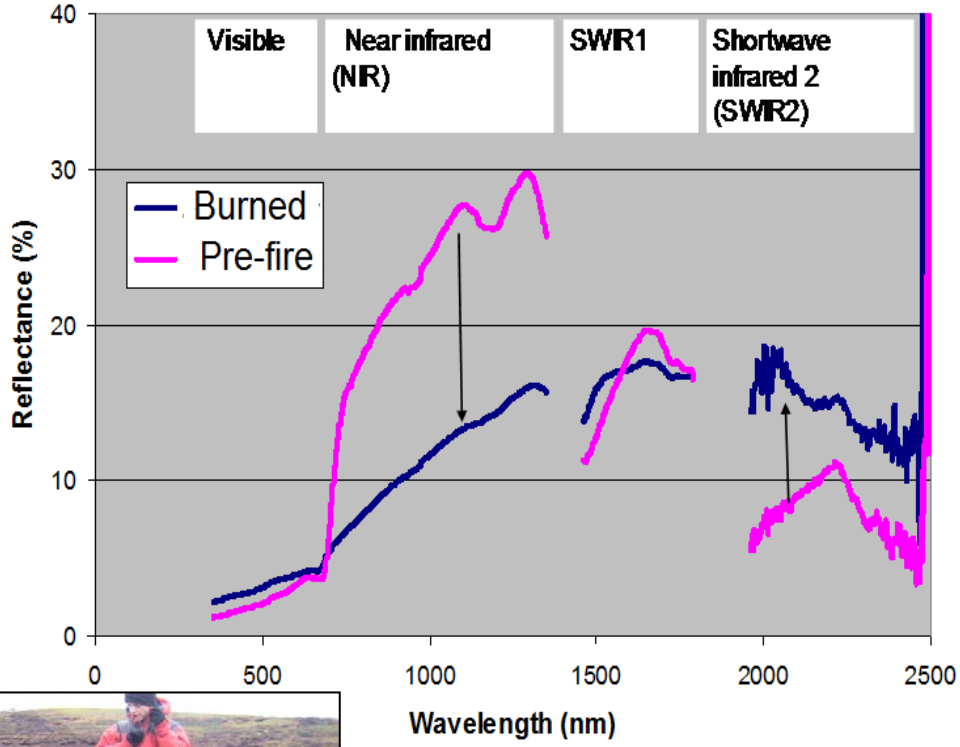
(g) ERS-2 24 May 2003 (144 JD) 36 days after fire
Precipitation during image acquisition = 0 mm
Three days before image acquisition = 20.6 mm

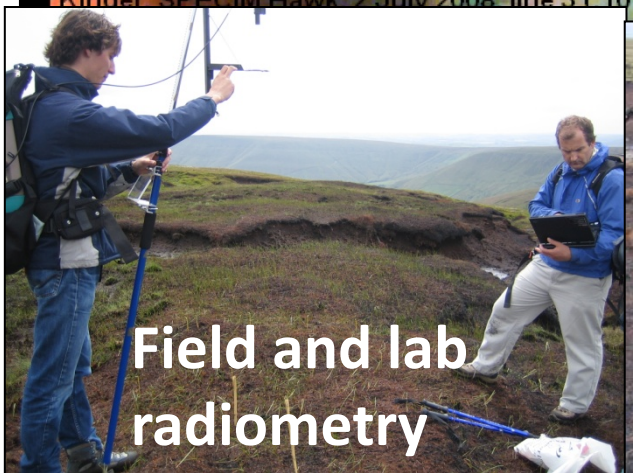
Bleaklow 18 April 2003, 7km^2 fire exposes peat. Rainfall on exposed peat enhances bright tones of fire signal up to 3 months afterwards (Millin-Chalabi *et al*., 2014)

Remote sensing of peat moorland fire severity

- Distinguishing burn severity using normalised burn ratio
- Works reasonably well, except where pre-existing exposed peat



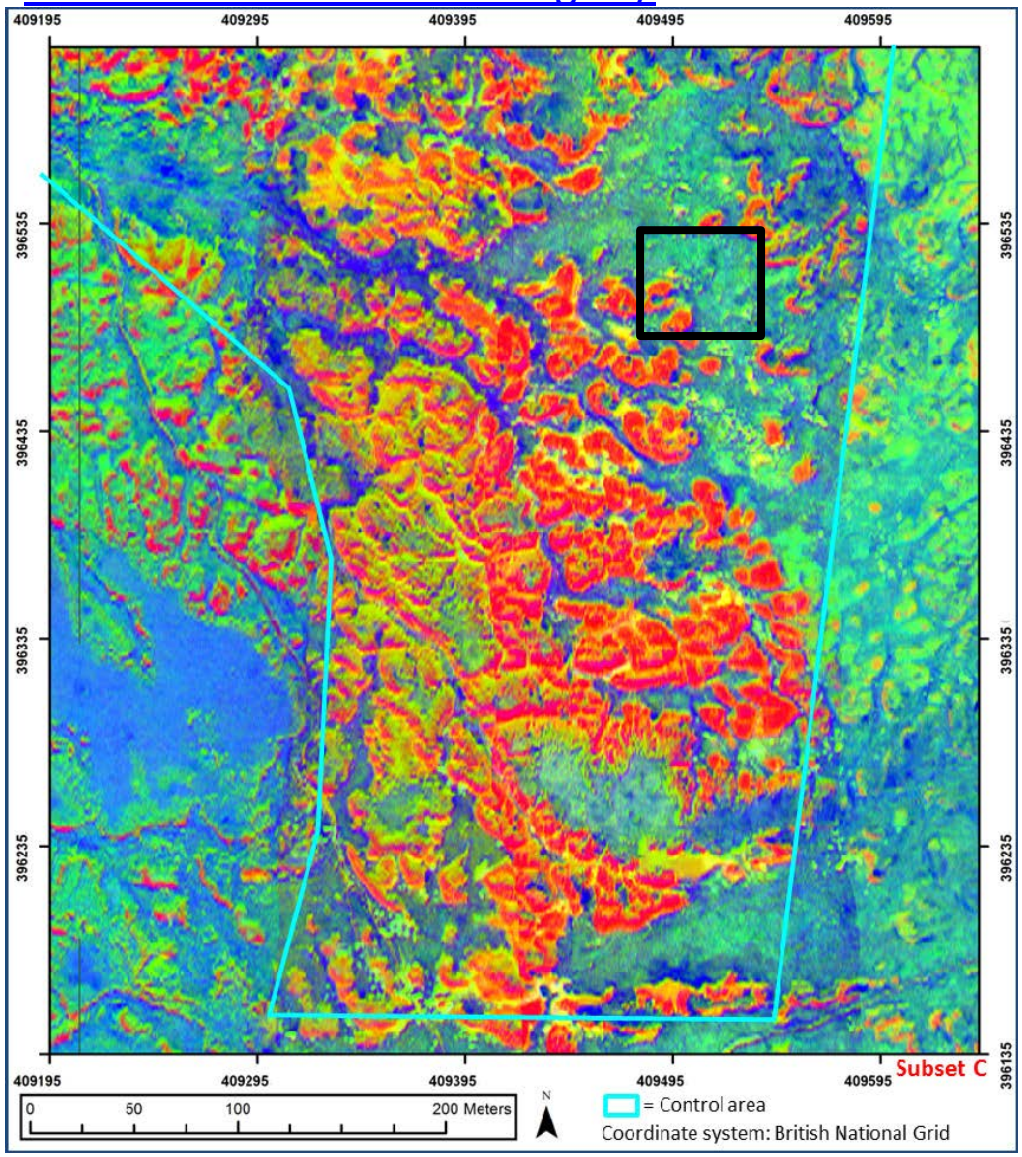




McMorrow *et al.* (2010)

High resolution remote sensing to monitor restoration of peatland wildfire burn scars

www.moorsforthefuture.org.uk/



False colour composite: predicted abundance of plant functional types using partial least-squares regression;

Bare peat (Red)

Bryophytes (Green)

Graminoids (Blue))

Cole et al. (2014) Remote Sensing, *6*, 716-739; doi:10.3390/rs6010716

Thank you for listening

Further information www.kfwf.org.uk