

# MODELLING THE SWINLEY-GROWTHORNE FOREST FIRE



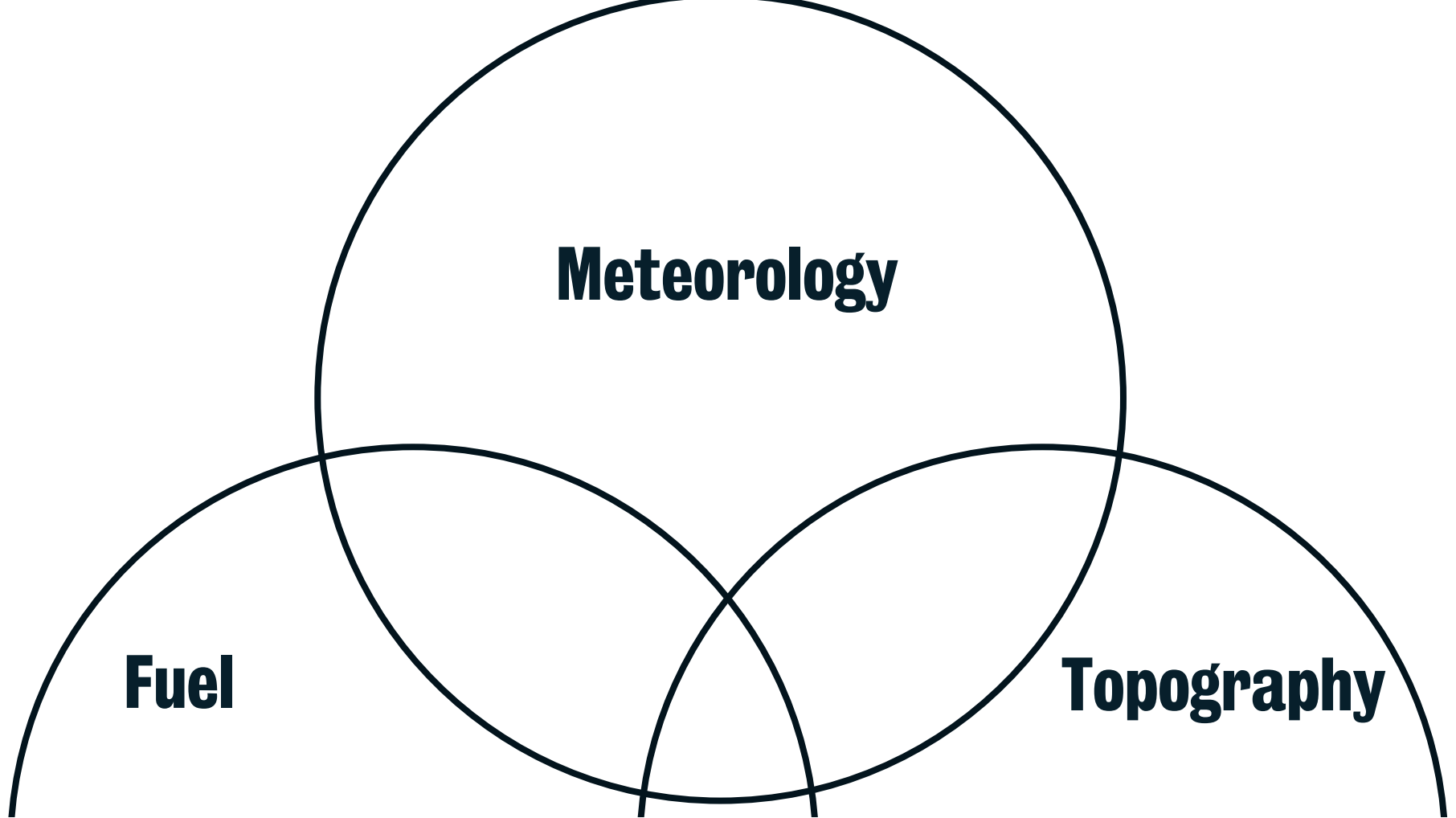
@DrTELS  
@KCLGEOGRAPHY

**Dr Thomas Smith**

*Department of Geography, King's College London*

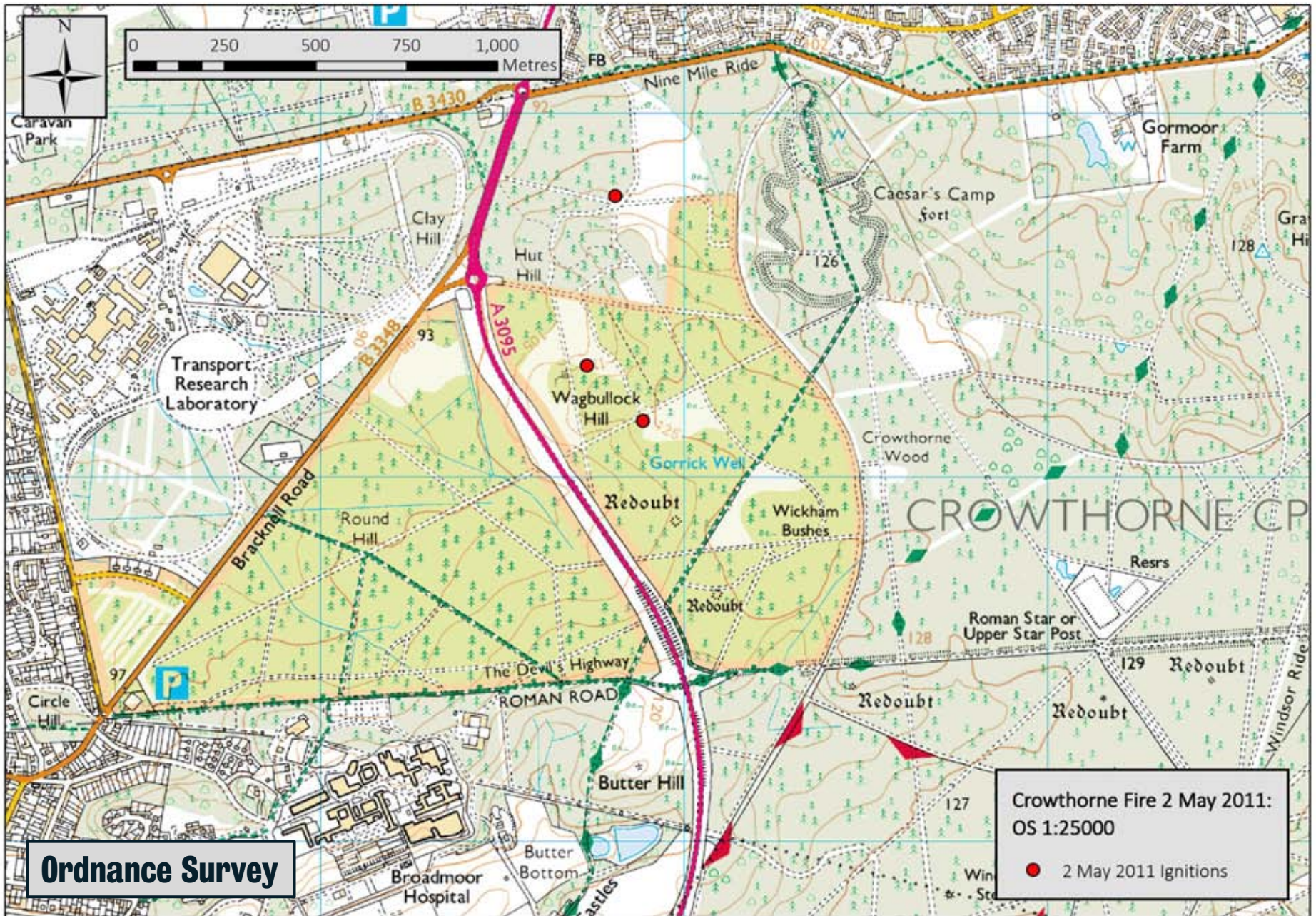
# OVERVIEW

- Model inputs
  - Fuels
  - Topography
  - Weather + modified weather
  - Ignition
- Wildfire spread models
  - Evaluation of modelled fire spread
- Fire spread vs observed spread
- Scenarios of wildfire spread



**FIRE SPREAD MODEL INPUTS**









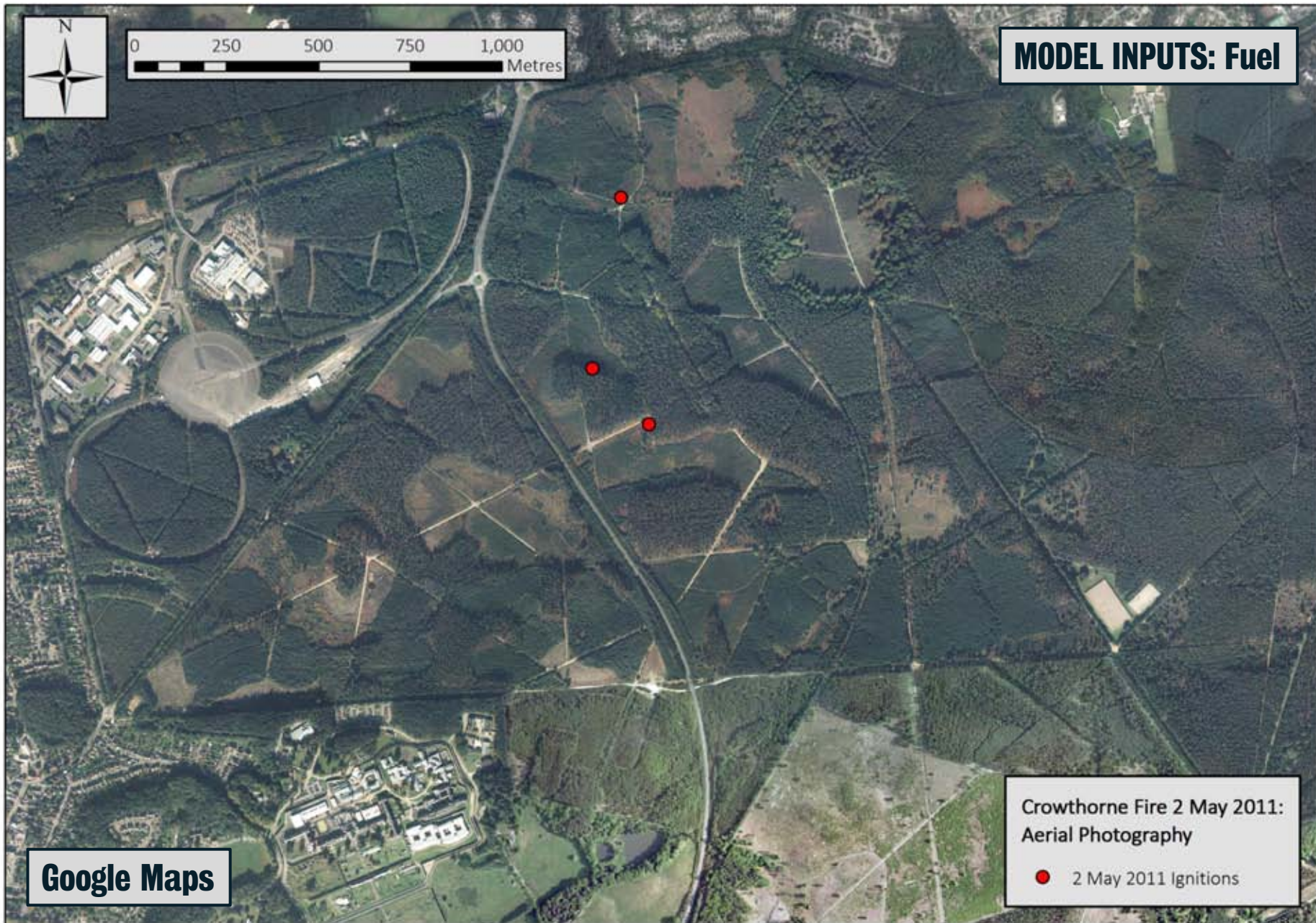
0 250 500 750 1,000  
Metres

## MODEL INPUTS: Fuel

Google Maps

Crowthorne Fire 2 May 2011:  
Aerial Photography

● 2 May 2011 Ignitions







0 250 500 750 1,000  
Metres

## MODEL INPUTS: Fuel



Crowthorne Fire 2 May 2011:  
fire extent reported by FCE

● 2 May 2011 Ignitions

### Forestry Commission Mapping

- Wet Heath
- Forest: Over 20 Years Old
- Forest: Under 20 Years Old





0 250 500 750 1,000  
Metres

## MODEL INPUTS: Fuel

**Prometheus fuel models:**  
**C4 – immature conifers**  
**C6 – conifer plantation**

**Crowthorne Fire 2 May 2011:**  
**Fire Habitats**

- High Risk - Conifer (under 20 years old)
- Low Risk - Conifer (over 20 years old)
- Low Risk - Lawns
- Low Risk - Wet Heath
- No Fuel
- 2 May 2011 Ignitions



0 250 500 750 1,000  
Metres

## MODEL INPUTS: Terrain

Crowthorne Fire 2 May 2011:  
Terrain

● 2 May 2011 Ignitions

DTM

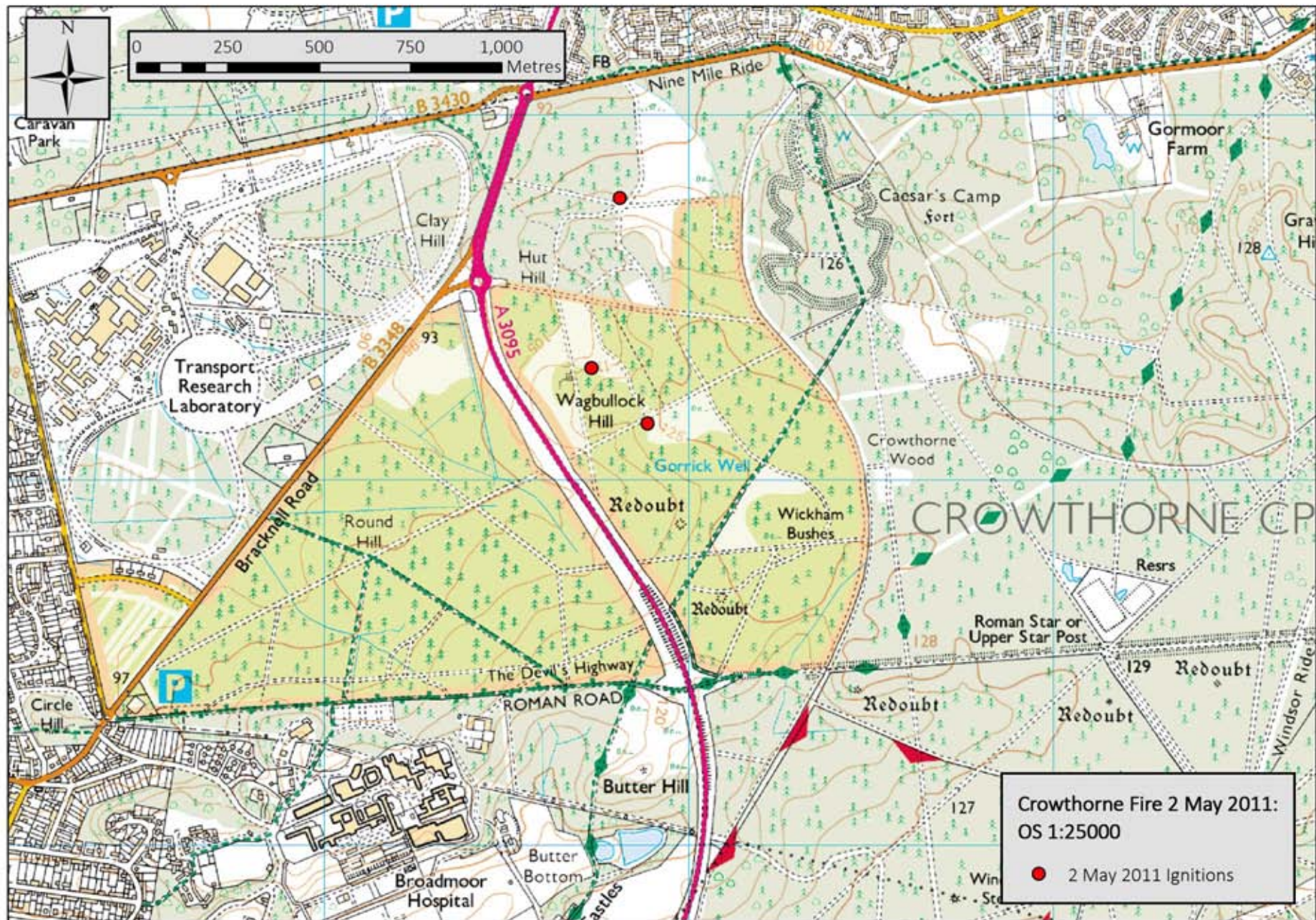
145 m



61 m

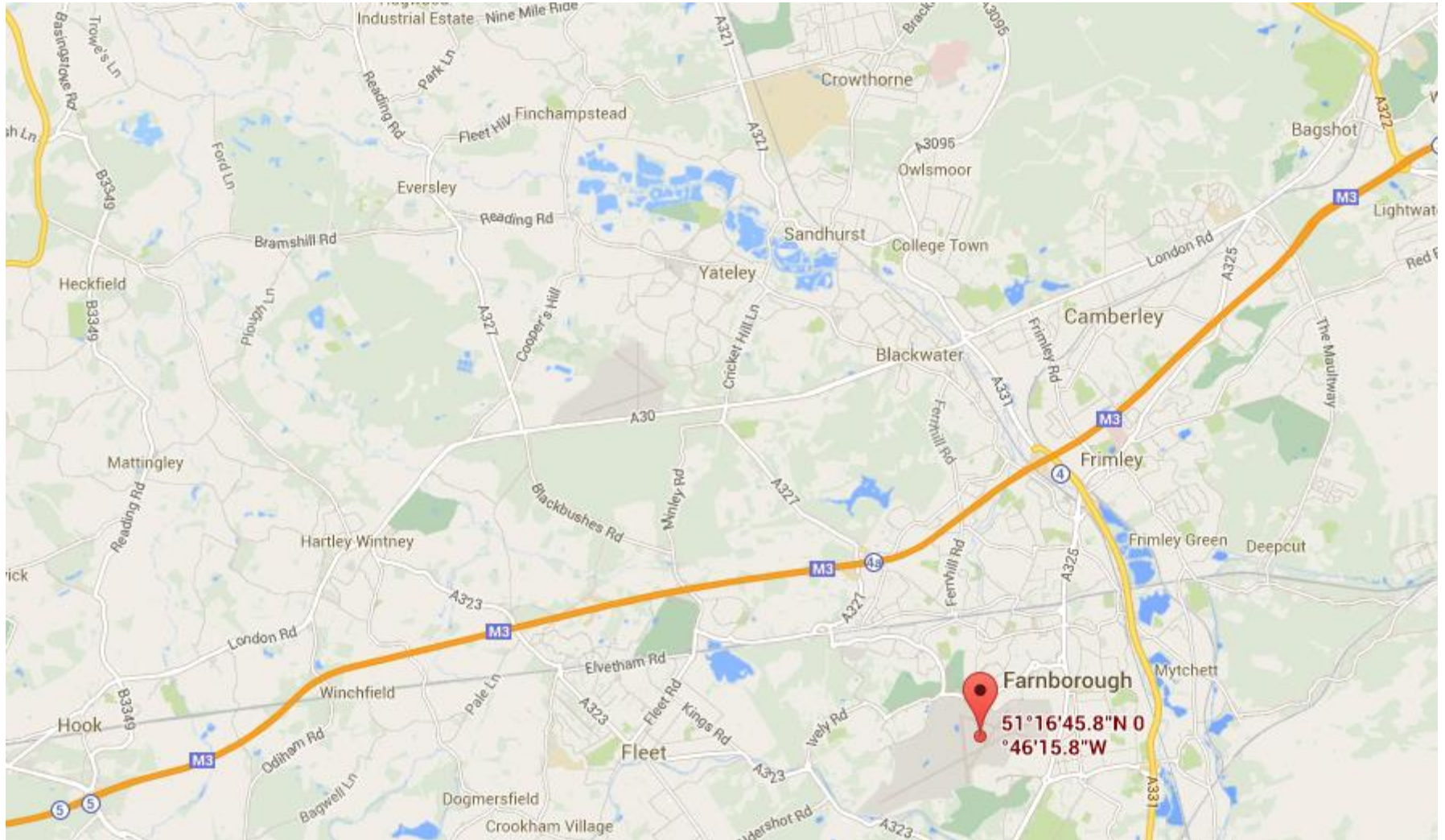
**NEXTmap 5 m DTM**





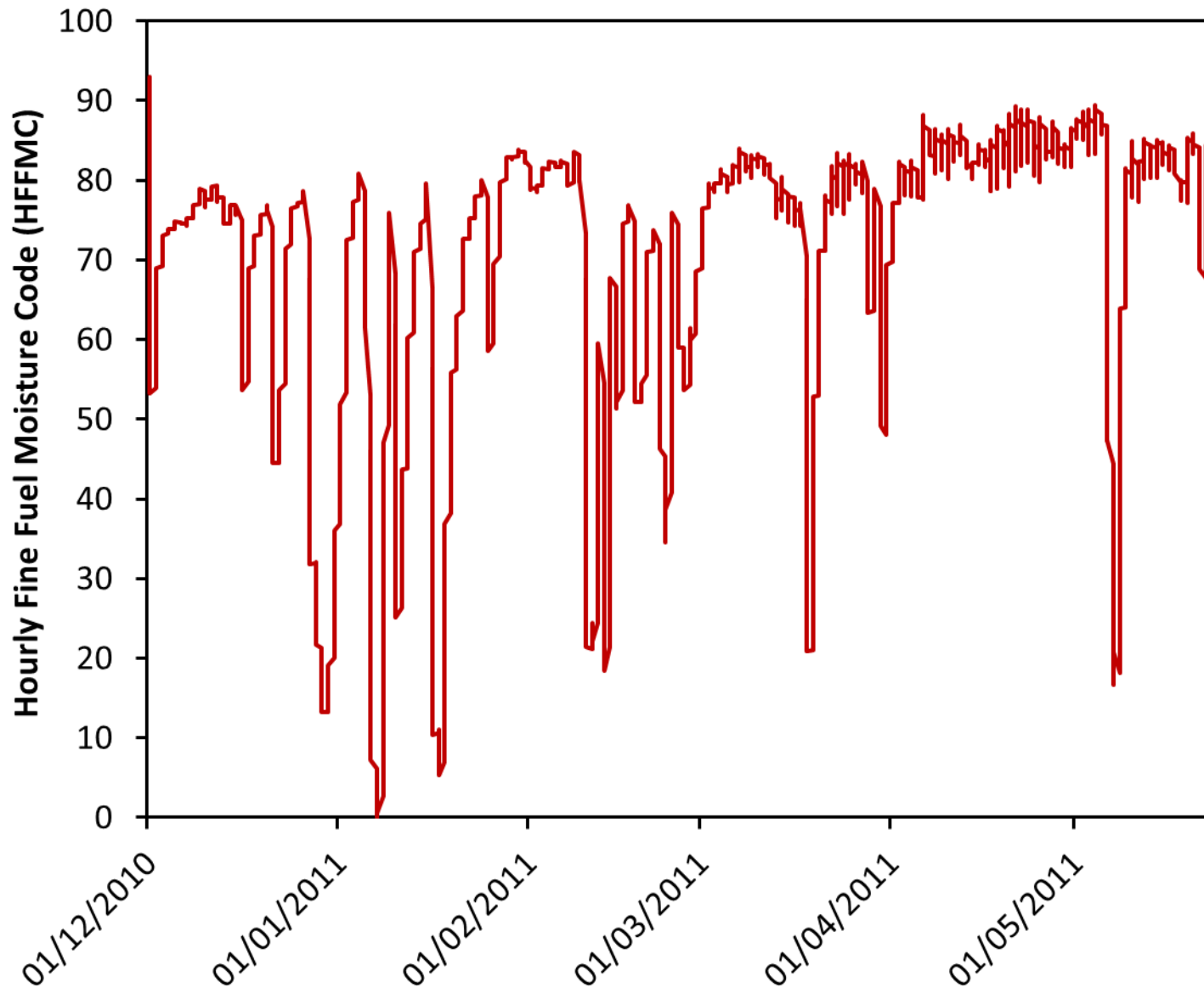


# MODEL INPUTS: LONG-TERM WEATHER

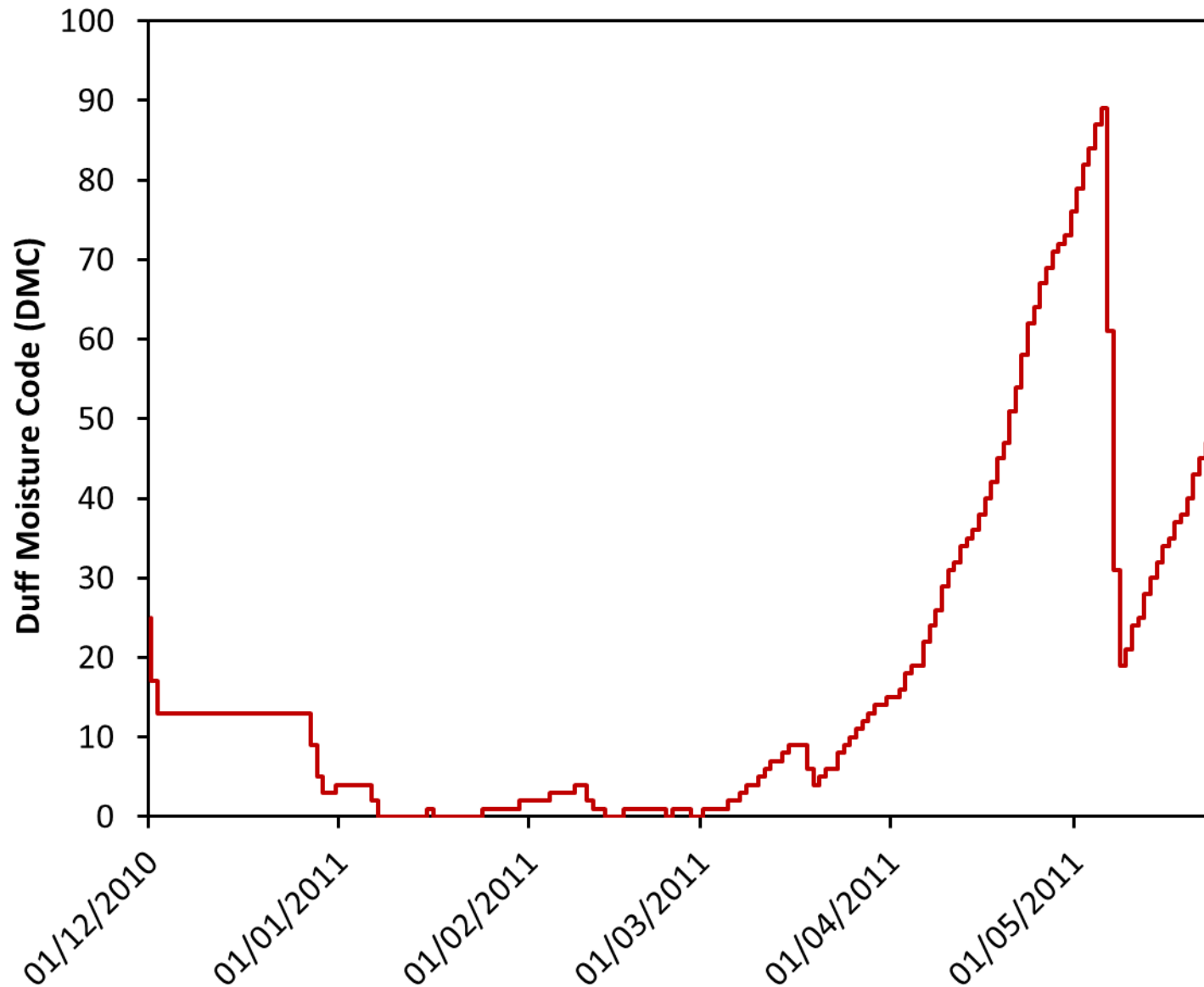




# MODEL INPUTS: LONG-TERM WEATHER

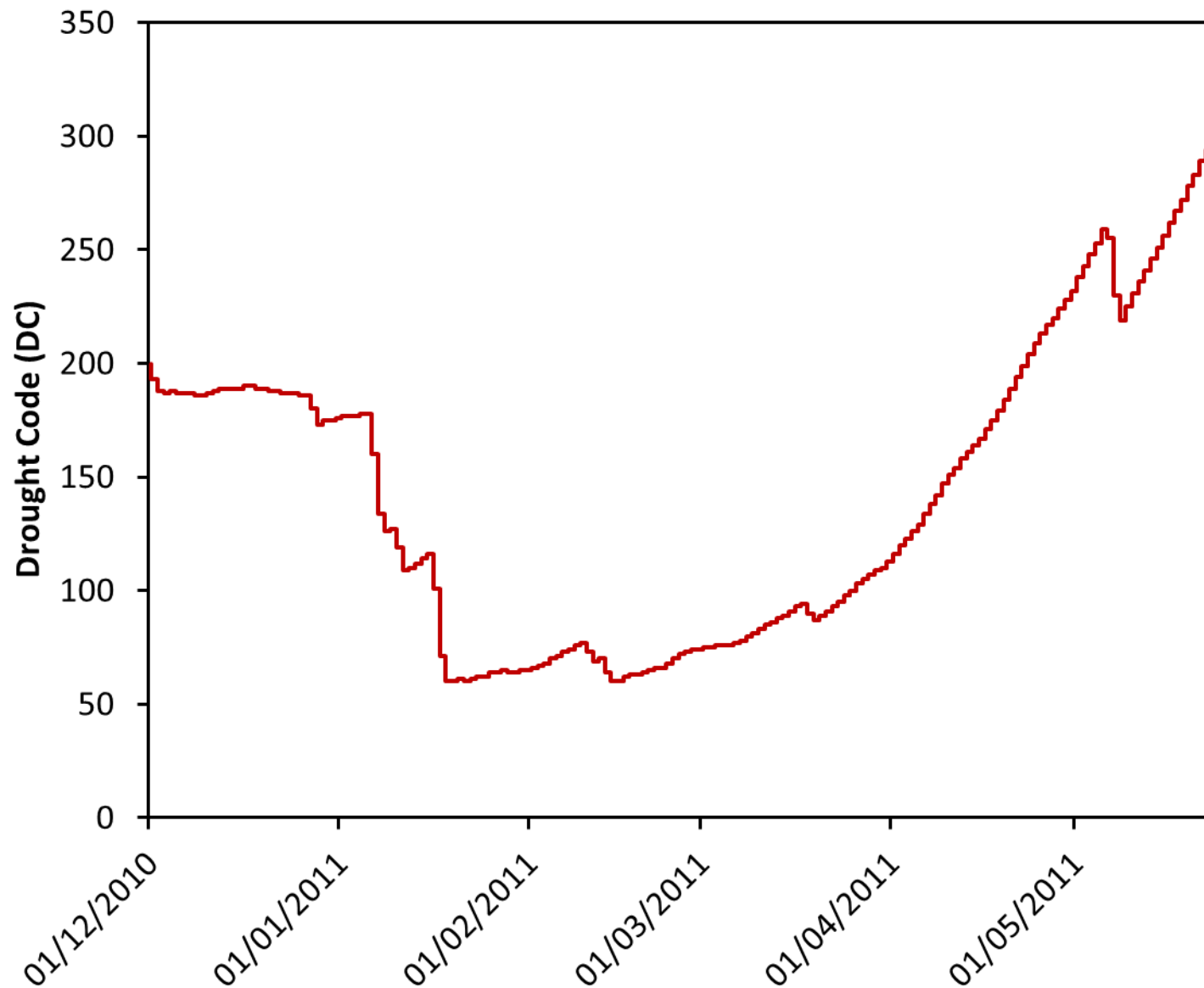


# MODEL INPUTS: LONG-TERM WEATHER

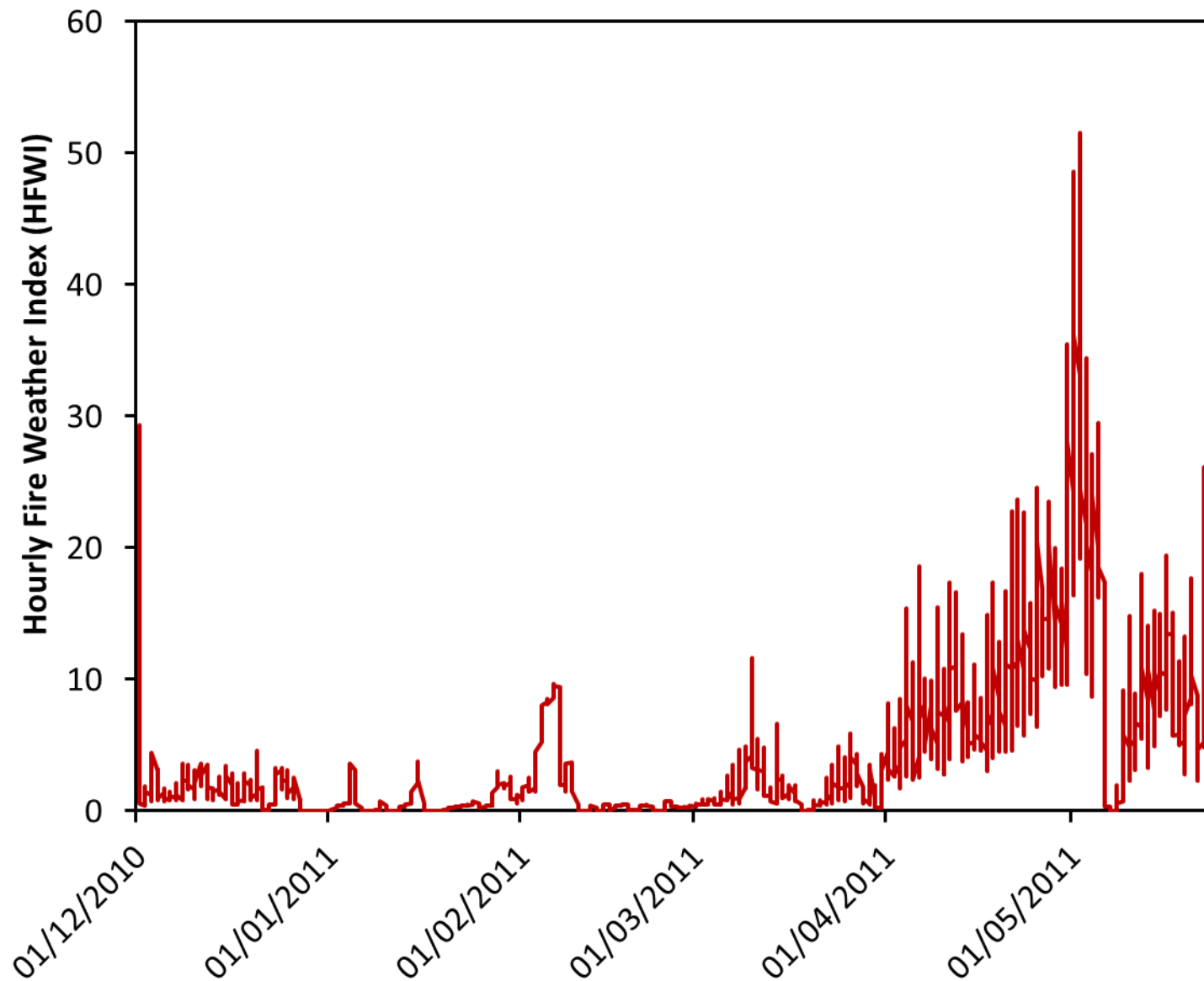




# MODEL INPUTS: LONG-TERM WEATHER

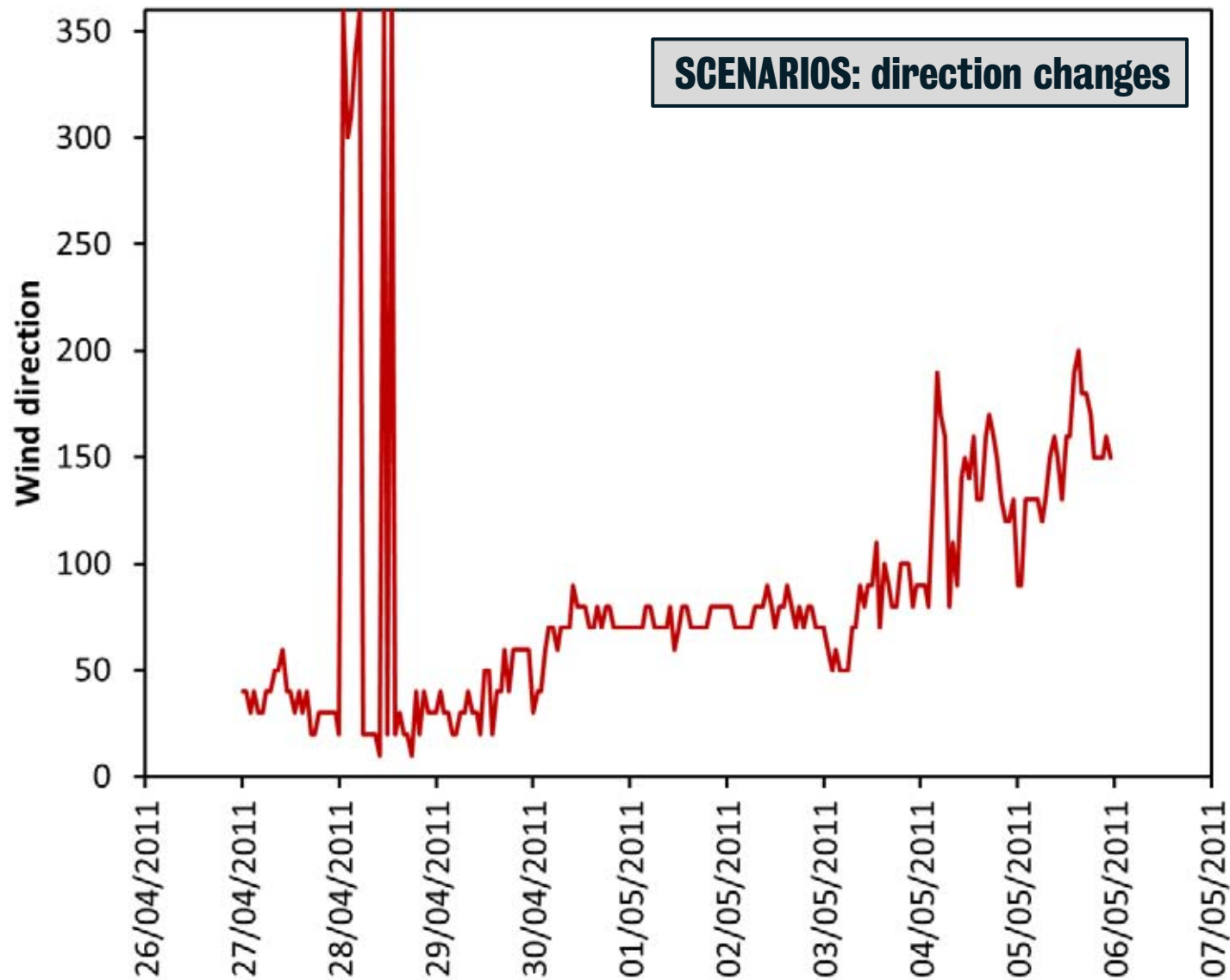


# MODEL INPUTS: LONG-TERM WEATHER

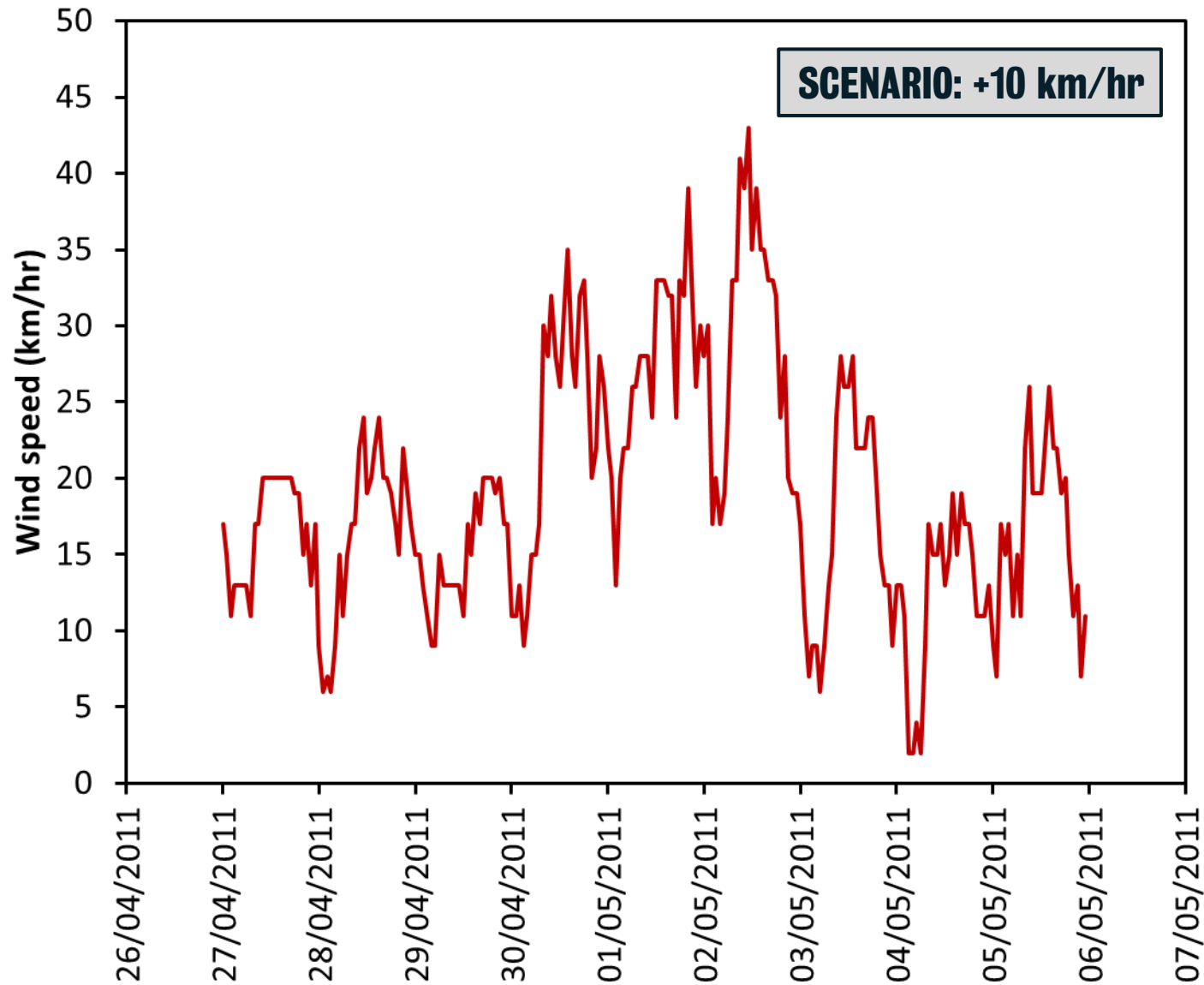




# FIRE WEATHER FOR CROWTHORNE FIRE: WIND DIRECTION

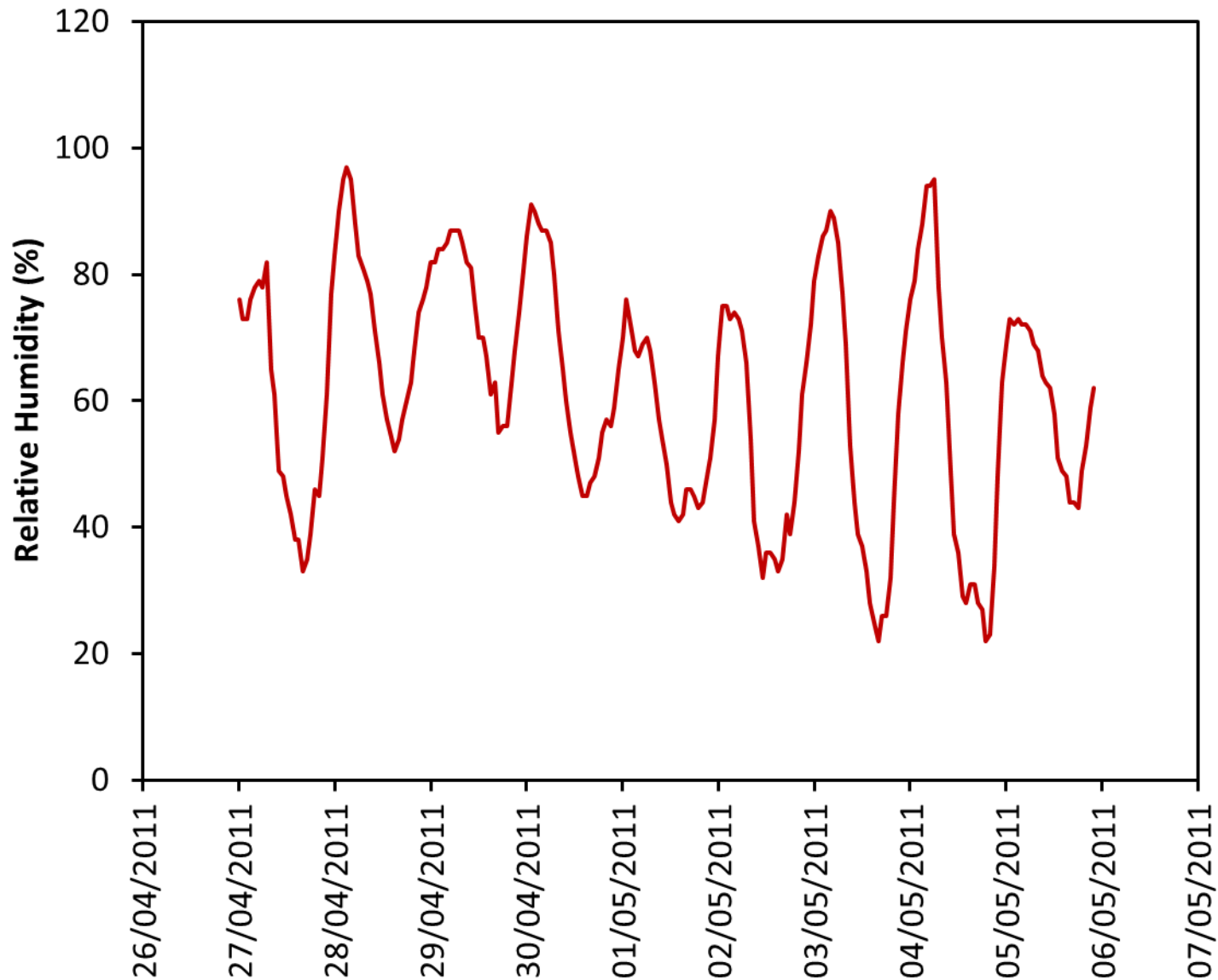


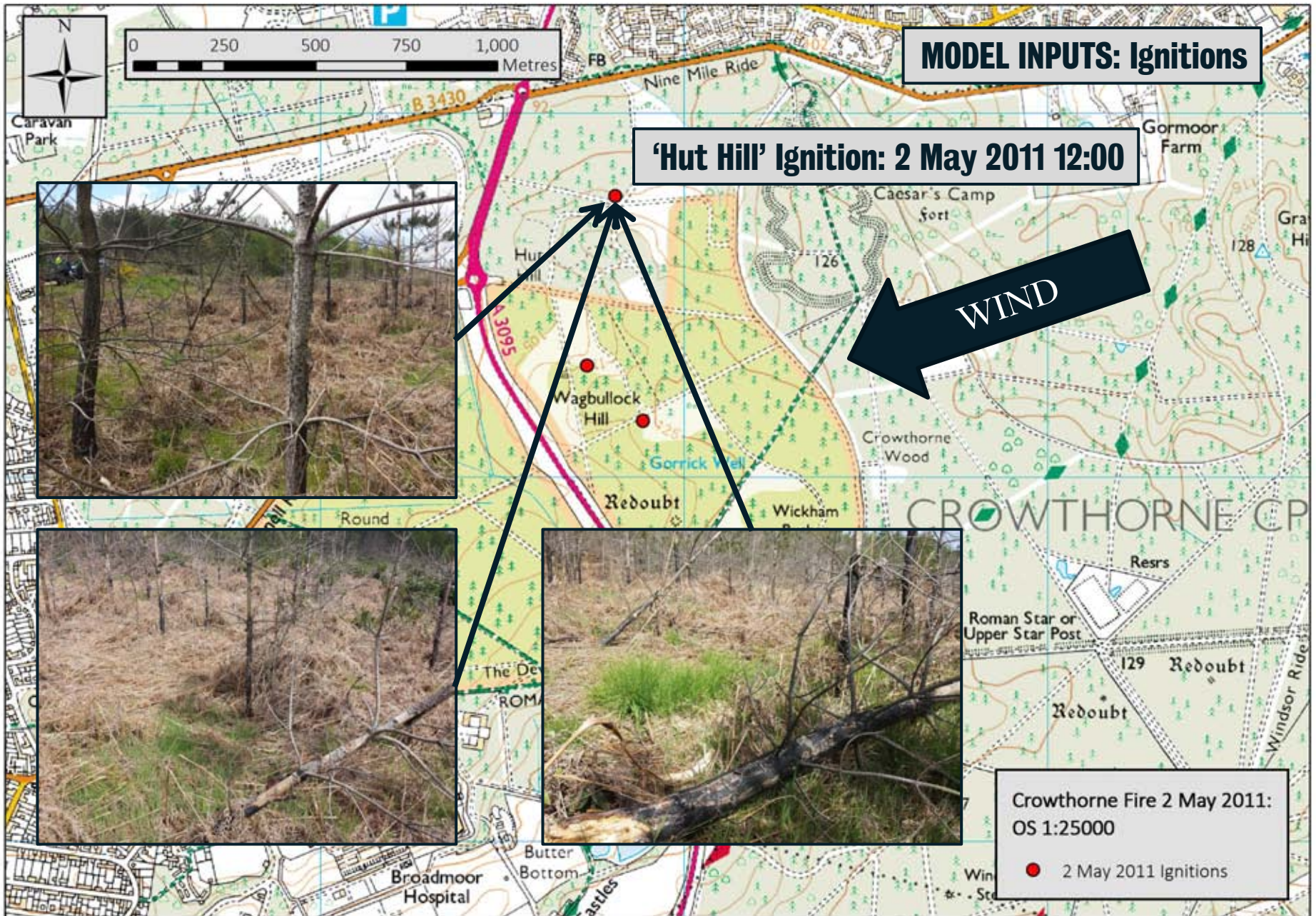
# FIRE WEATHER FOR CROWTHORNE FIRE: WIND SPEED



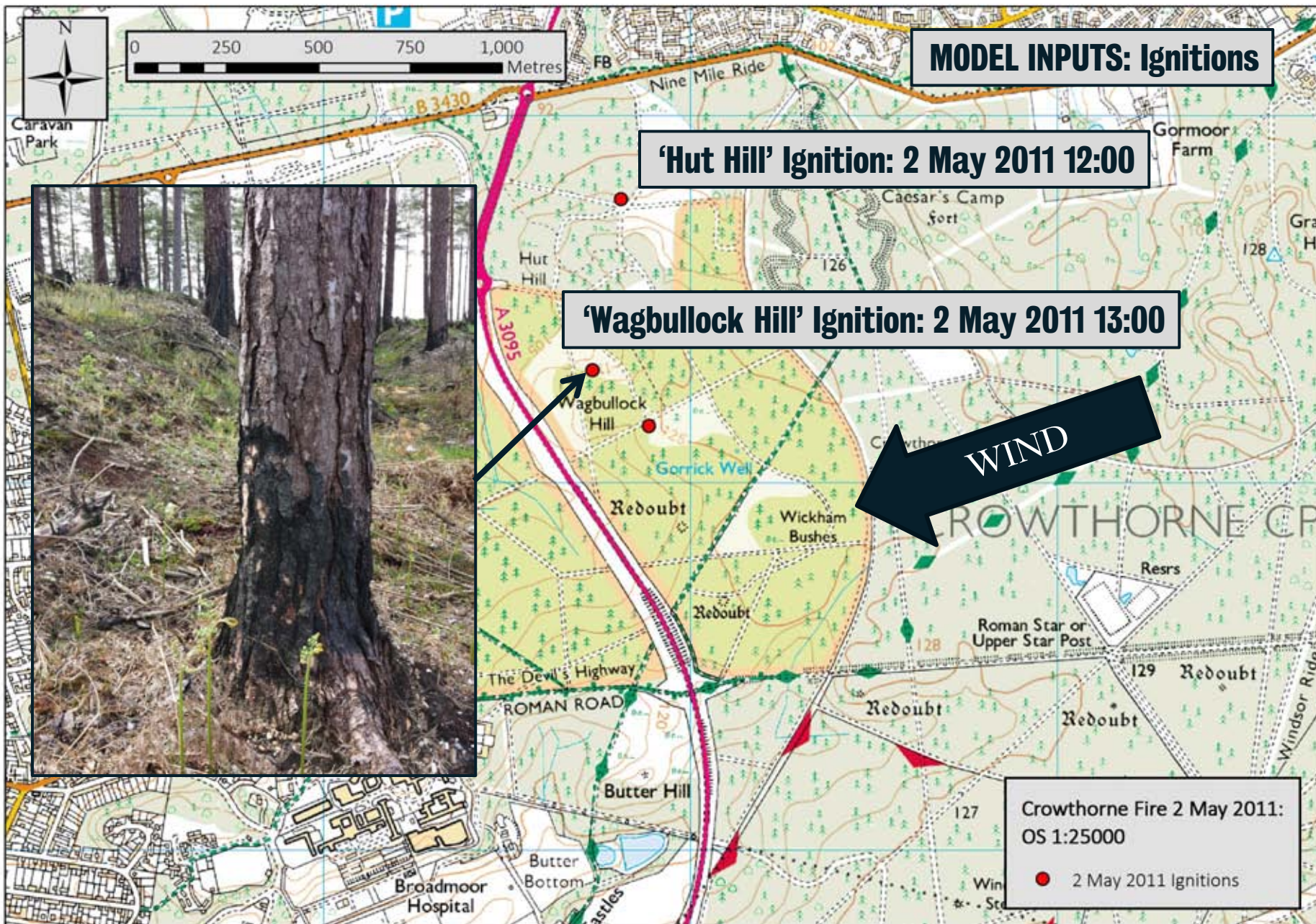


# FIRE WEATHER FOR CROWTHORNE FIRE: RH

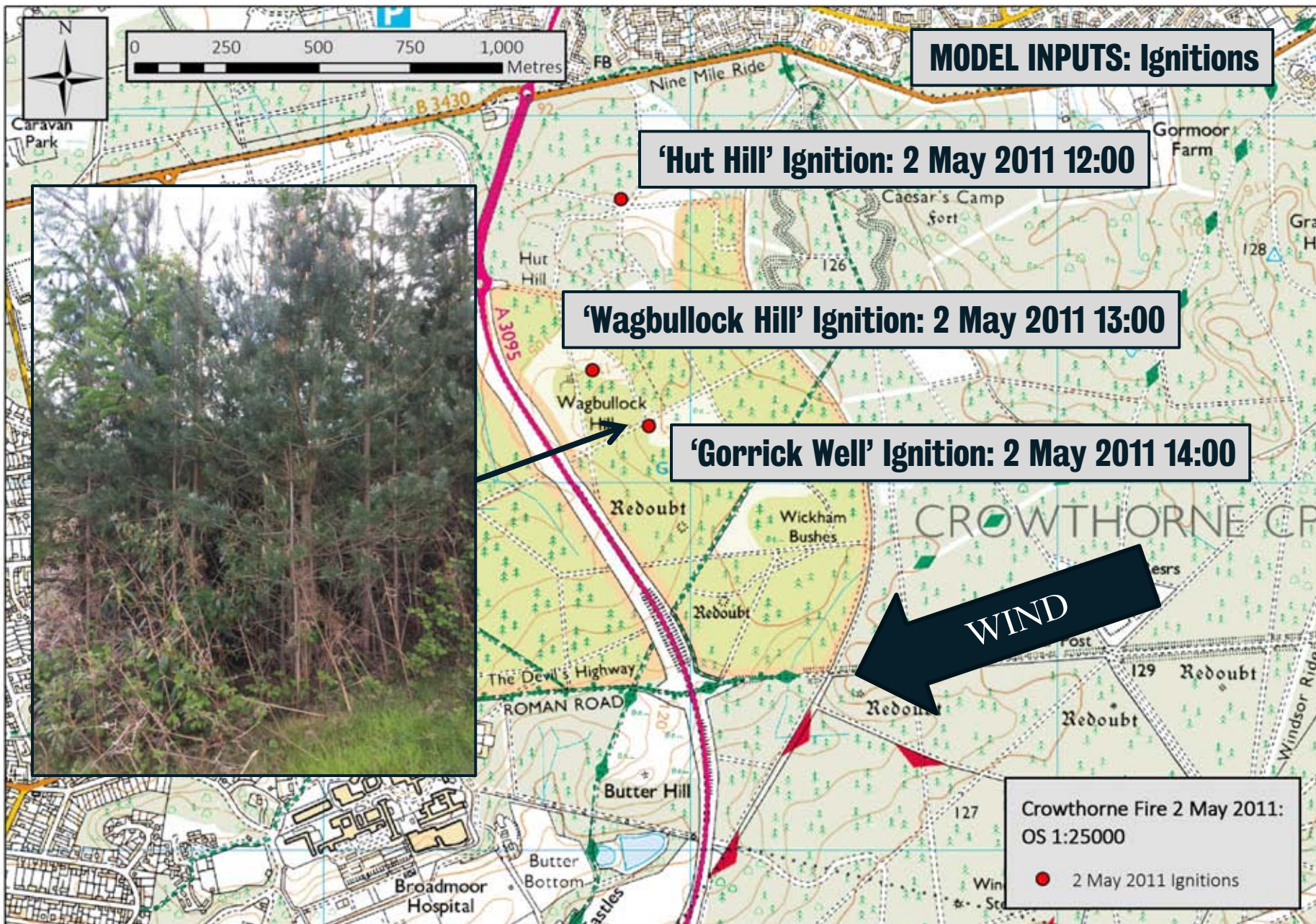










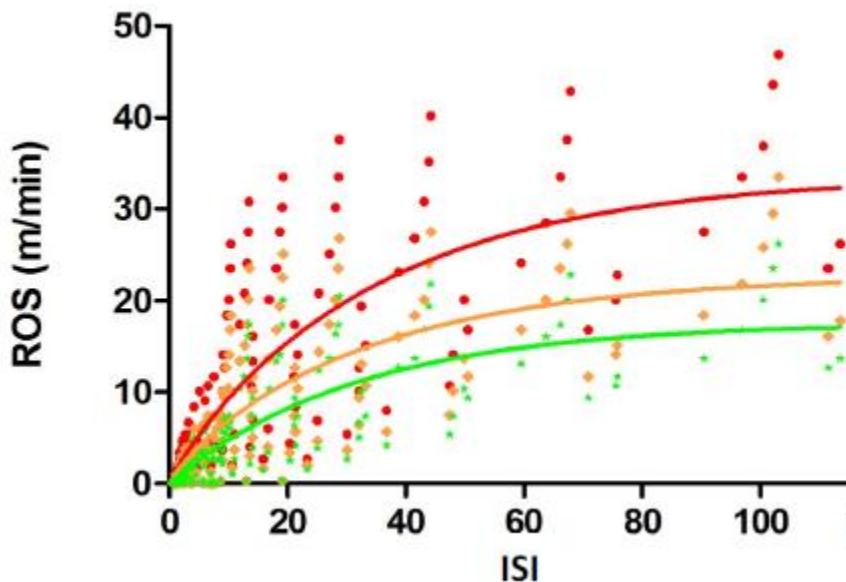
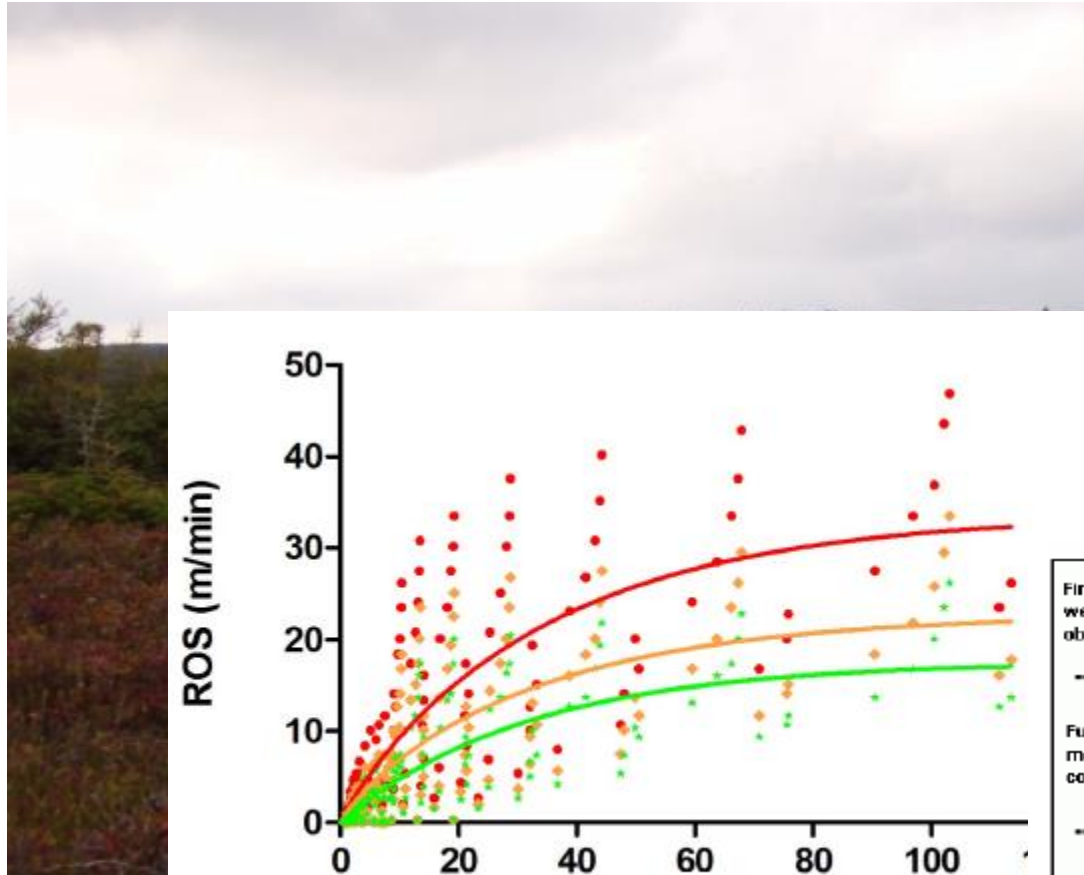




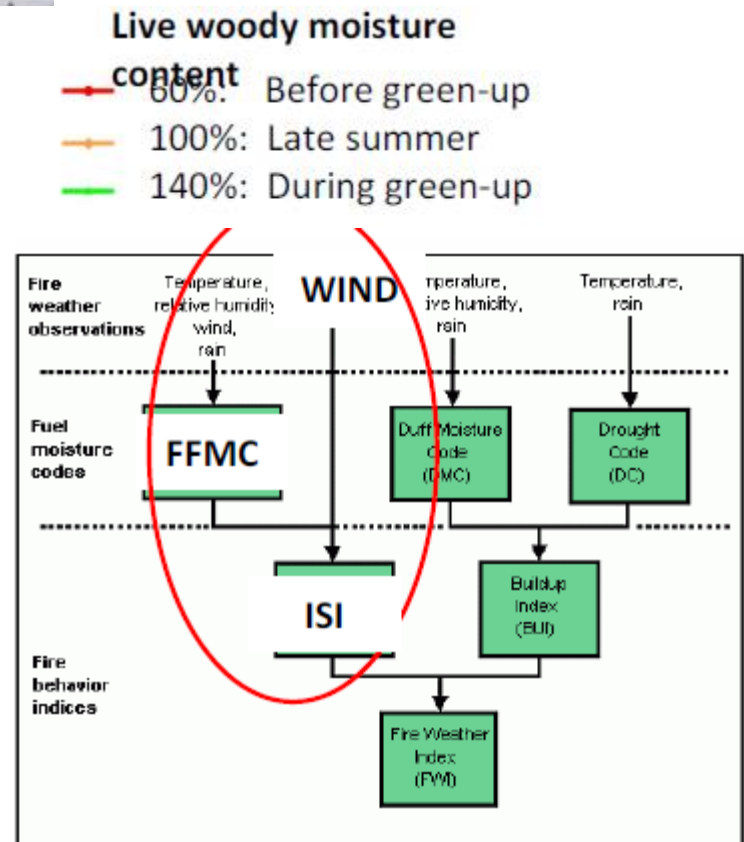


# **FIRE SPREAD MODELLING**

# FUEL MODELS AND FIRE SPREAD IN PROMETHEUS



Empirical relationships between Canadian FWI parameters and ROS/FI





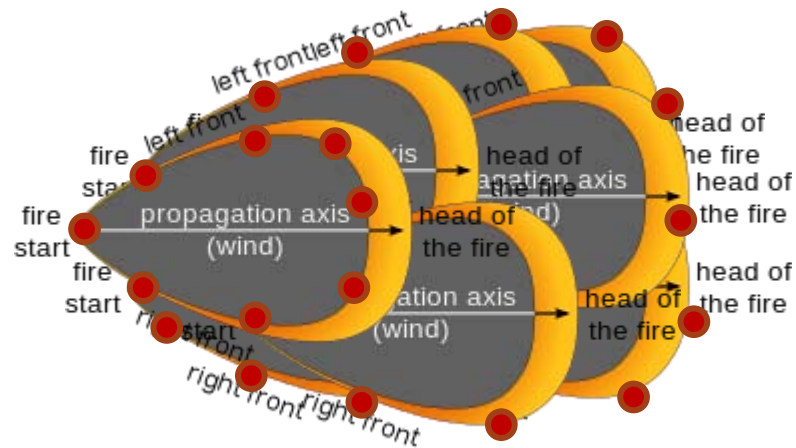
# FUEL MODELS AND FIRE SPREAD IN FARSITE

FM Code	FUEL LOADING (tons ha <sup>-1</sup> )					SURFACE AREA:VOLUME (cm <sup>2</sup> cm <sup>-3</sup> )			DEPTH (cm)	XtMoist (%)	HEAT CONTENT (kJ Kg <sup>-1</sup> )	
	1h	10h	100h	LH	LW	1h	LH	LW			Live	Dead
FM14 (HIGH)	2.73	0	0	0	12.17	96	88	100	42.4	25	20808	20808
FM14 (LOW)	1.28	0	0	0	6.5	96	88	100	19.7	25	20808	20808
SH6 (HIGH)	7.16	3.58	0	0	3.46	246	N/A	525	61	30	18608	18608
SH3 (LOW)	1.11	7.41	0	0	15.32	525	N/A	459	73	40	18608	18608

**FM14:** customised fuel model for heather (Davies, 2005)

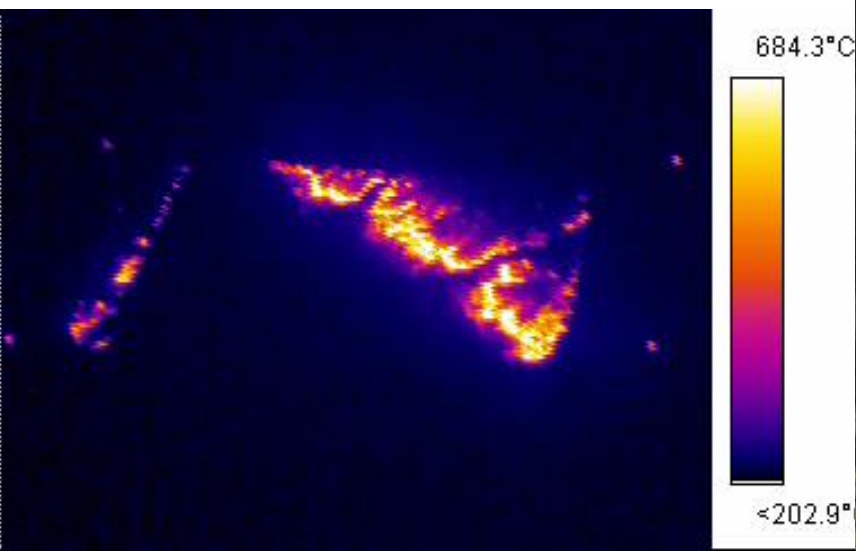
**SH6/SH3:** 'built-in' FARSITE fuel model for shrubs (Scott & Burgan, 2005)

# PROPAGATION





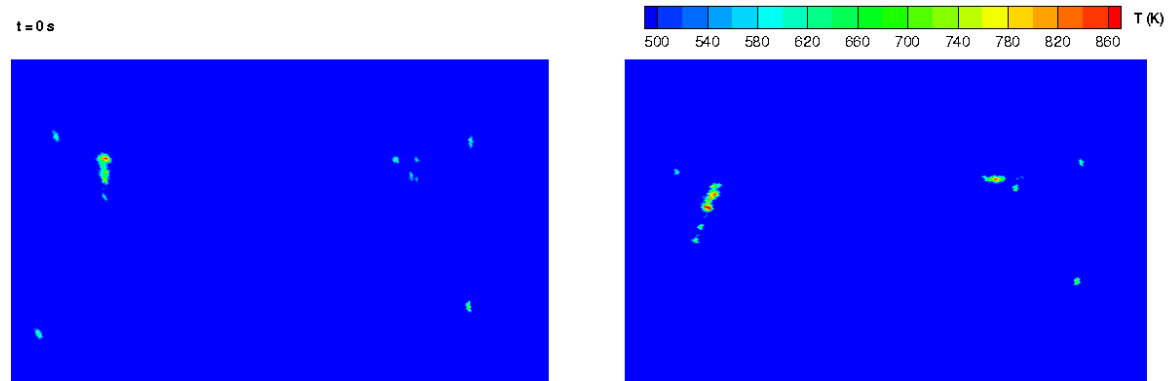
# EVALUATING/ CUSTOMISING FUEL MODELS



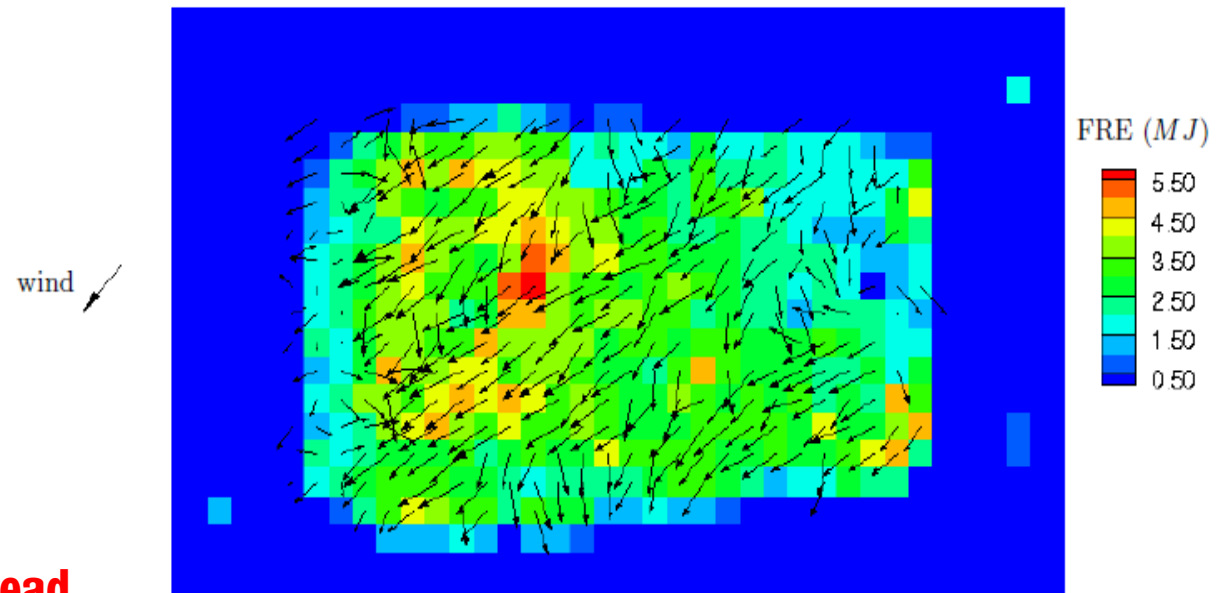
# EVALUATING/CUSTOMISING FUEL MODELS

945 m<sup>2</sup> plot of heather

Methodology to geo-reference thermal imagery



$\vec{u}_{ros} (m\ s^{-1})$



Paugam *et al.* (2013) IEEE Trans.

Tool to study and derive  
**Energy Transfer** **Rate Of Spread**

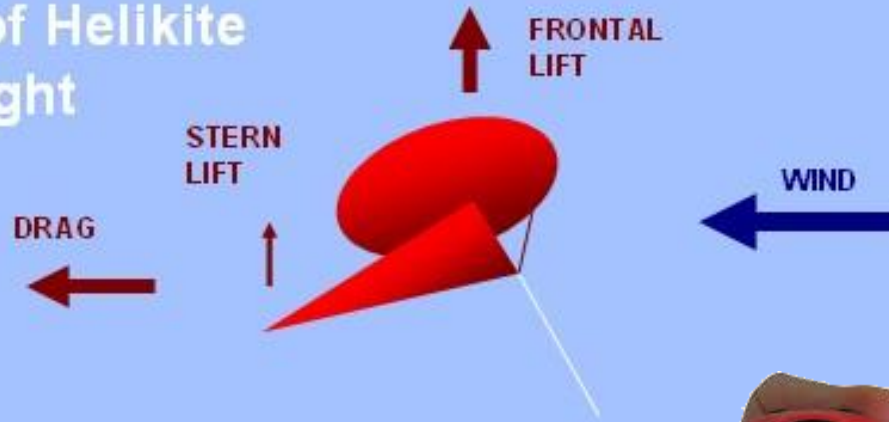


# UAV FUEL MAPS AND FUEL MODEL EVALUATION



# WHAT ABOUT HELIKITES?

## Theory of Helikite Flight





# NEW MOOR BURN: 20 OCTOBER 2014

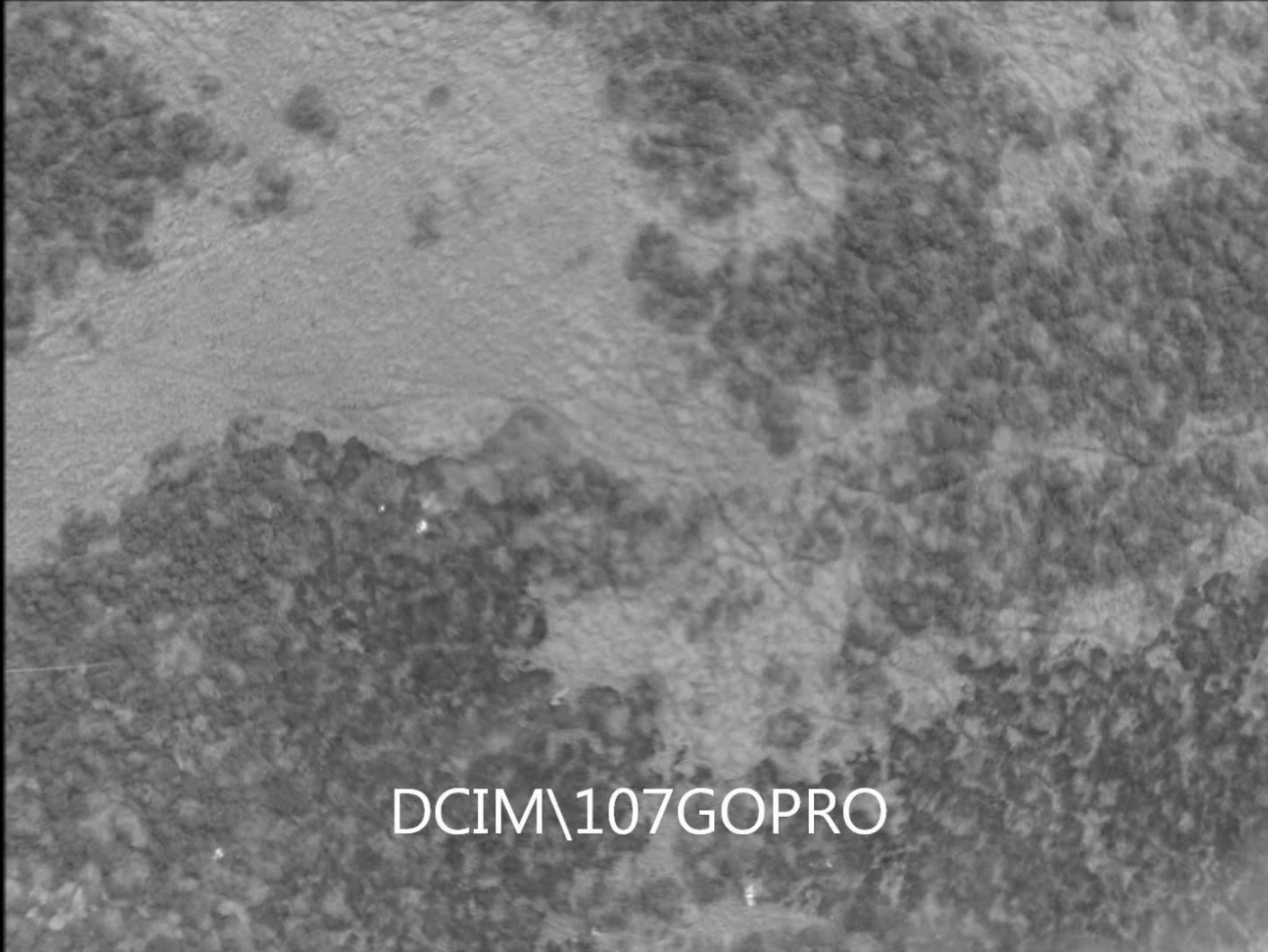




# BURNSIDE FIRES: 2 APRIL 2015



# BURNSIDE FIRES: 2 APRIL 2015



DCIM\107GOPRO





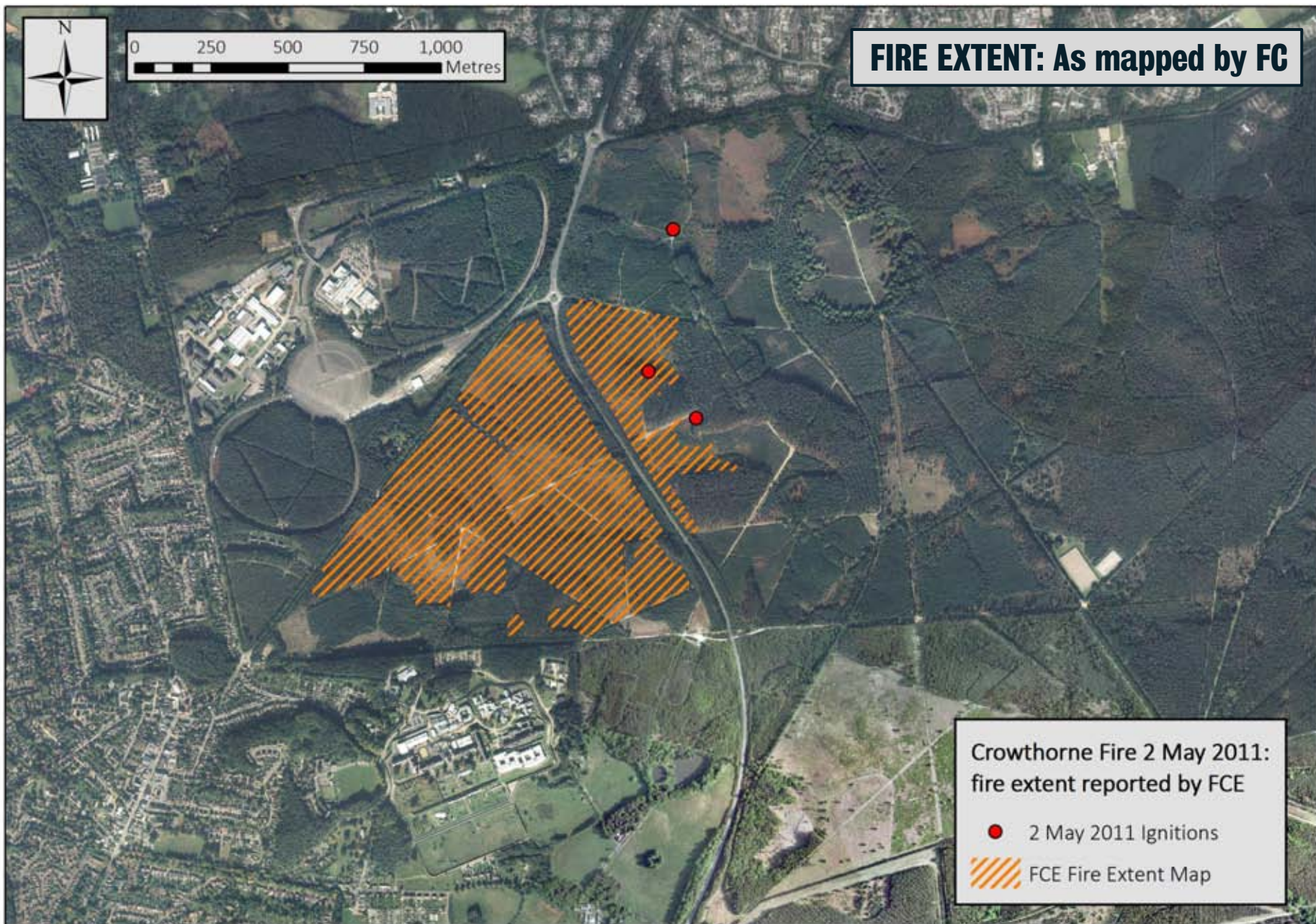
## **FIRE SPREAD MODELLING FOR SWINLEY-CROWTHORNE**





0 250 500 750 1,000  
Metres

## FIRE EXTENT: As mapped by FC

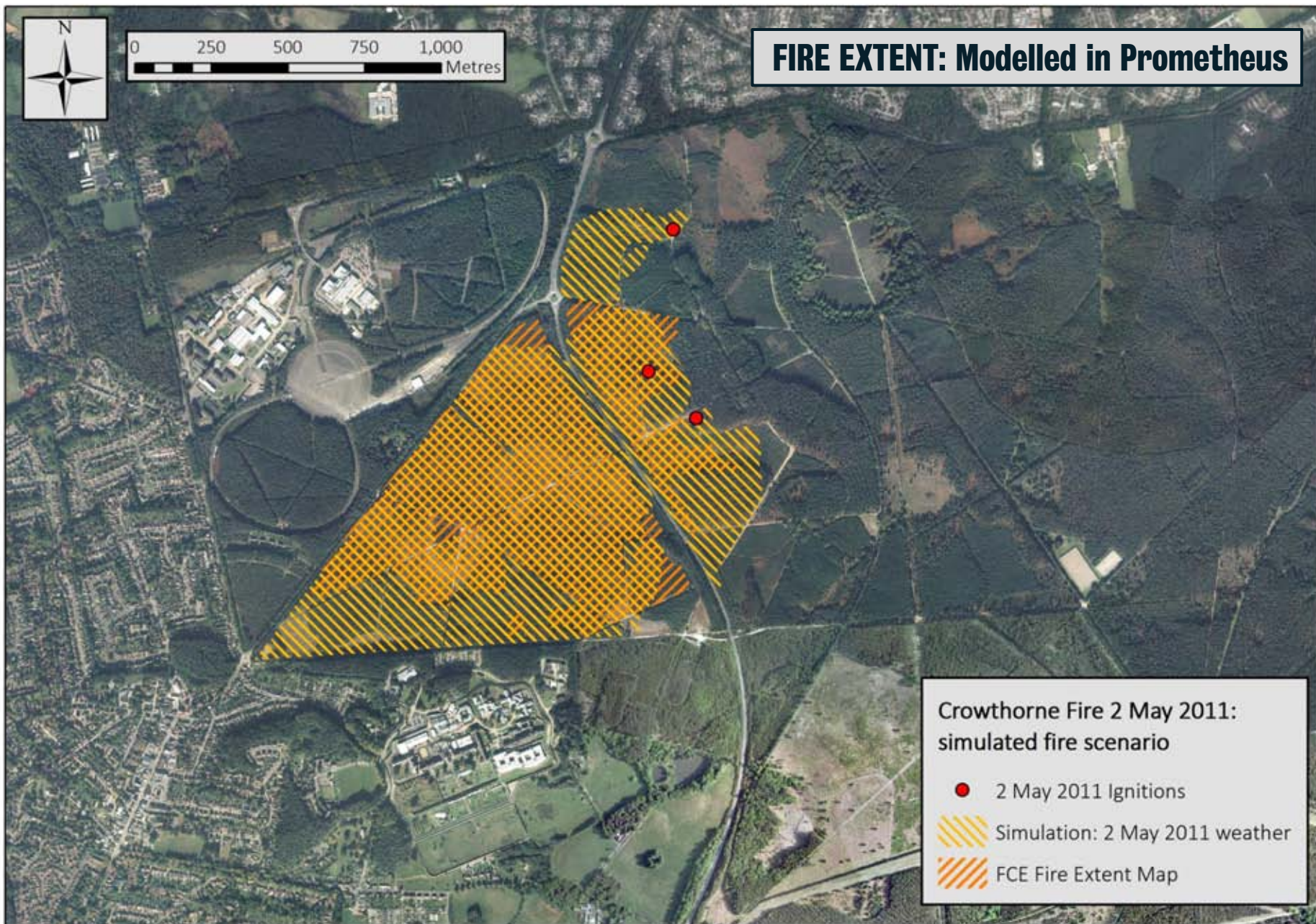






0 250 500 750 1,000  
Metres

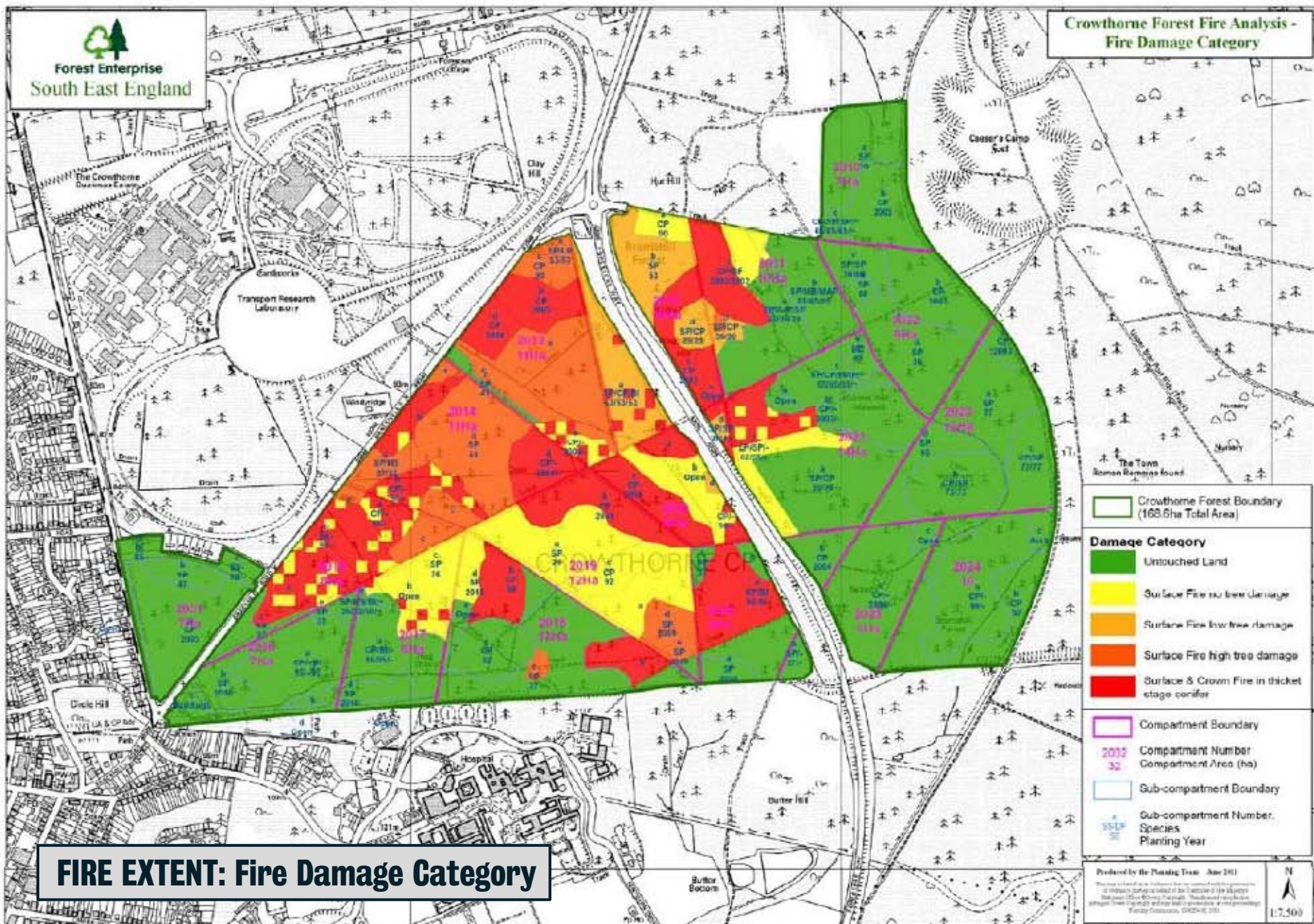
## FIRE EXTENT: Modelled in Prometheus



Crowthorne Fire 2 May 2011:  
simulated fire scenario

- 2 May 2011 Ignitions
- Simulation: 2 May 2011 weather
- FCE Fire Extent Map



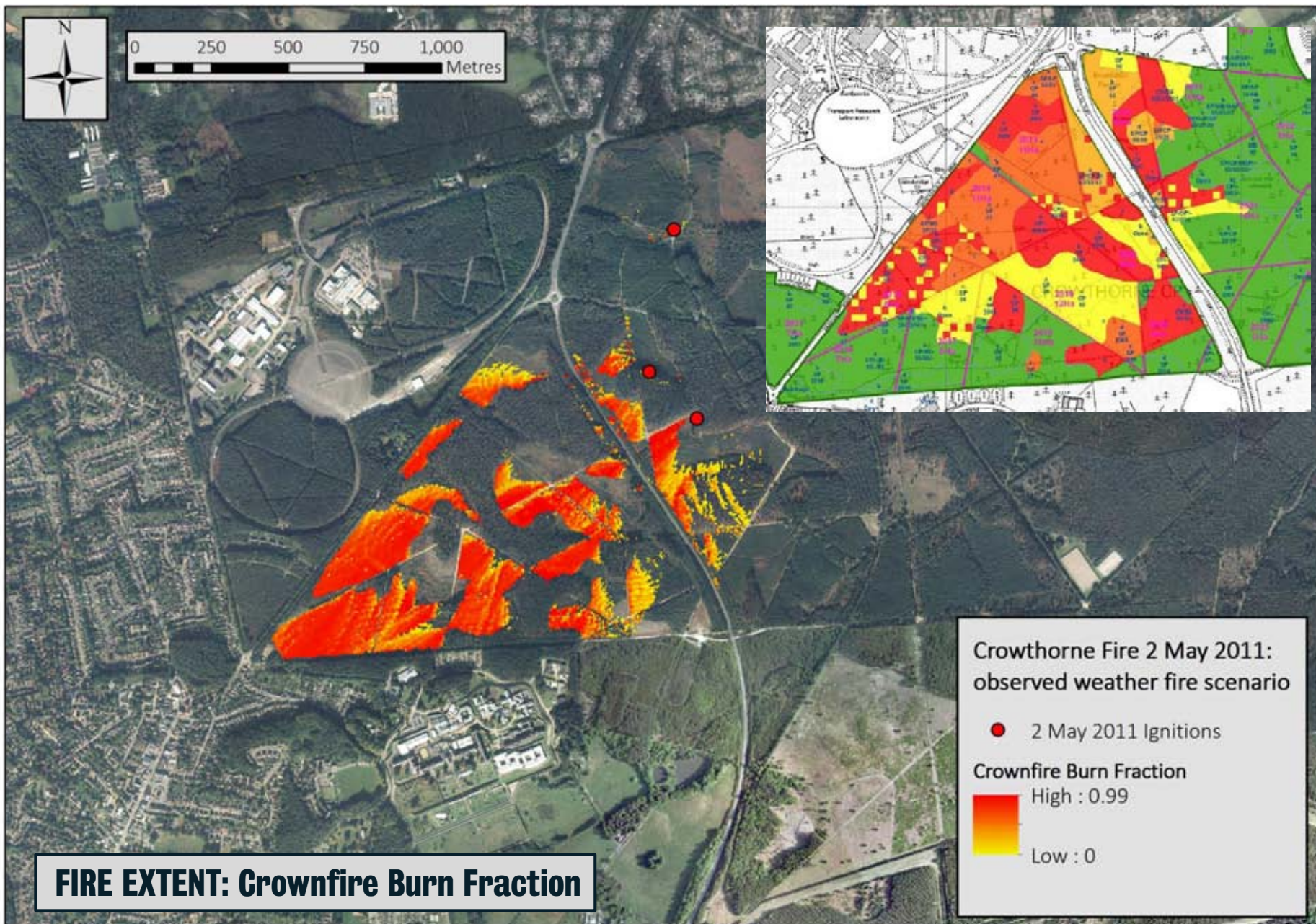


**FIRE EXTENT: Fire Damage Category**





0 250 500 750 1,000 Metres







0 250 500 750 1,000  
Metres

## FIRE EXTENT: Fire Intensity



Crowthorne Fire 2 May 2011:  
observed weather fire scenario

● 2 May 2011 Ignitions

Fire Intensity (kW/m)

HIGH: 26,000

Low: 0



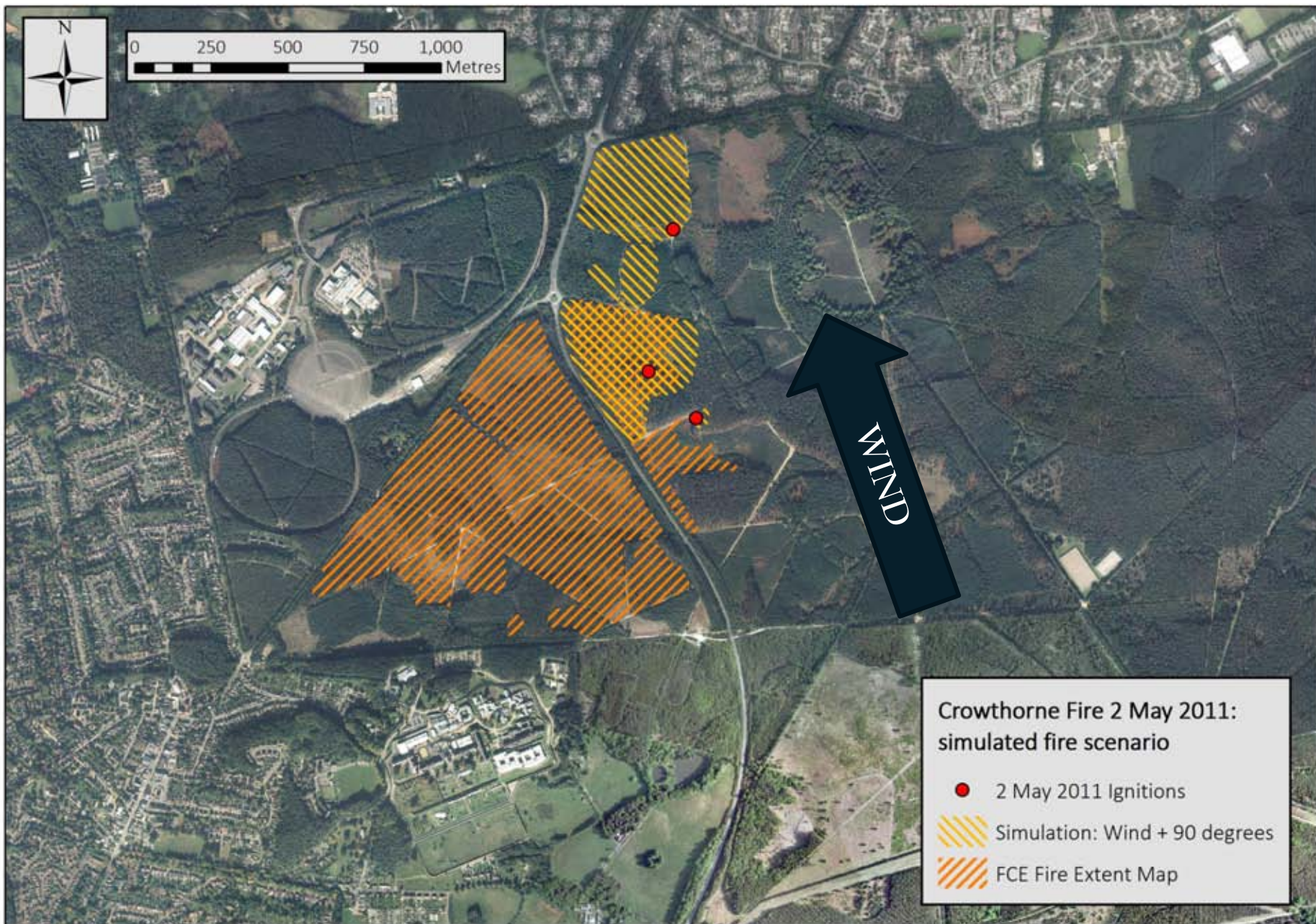


## ALTERNATIVE SCENARIOS





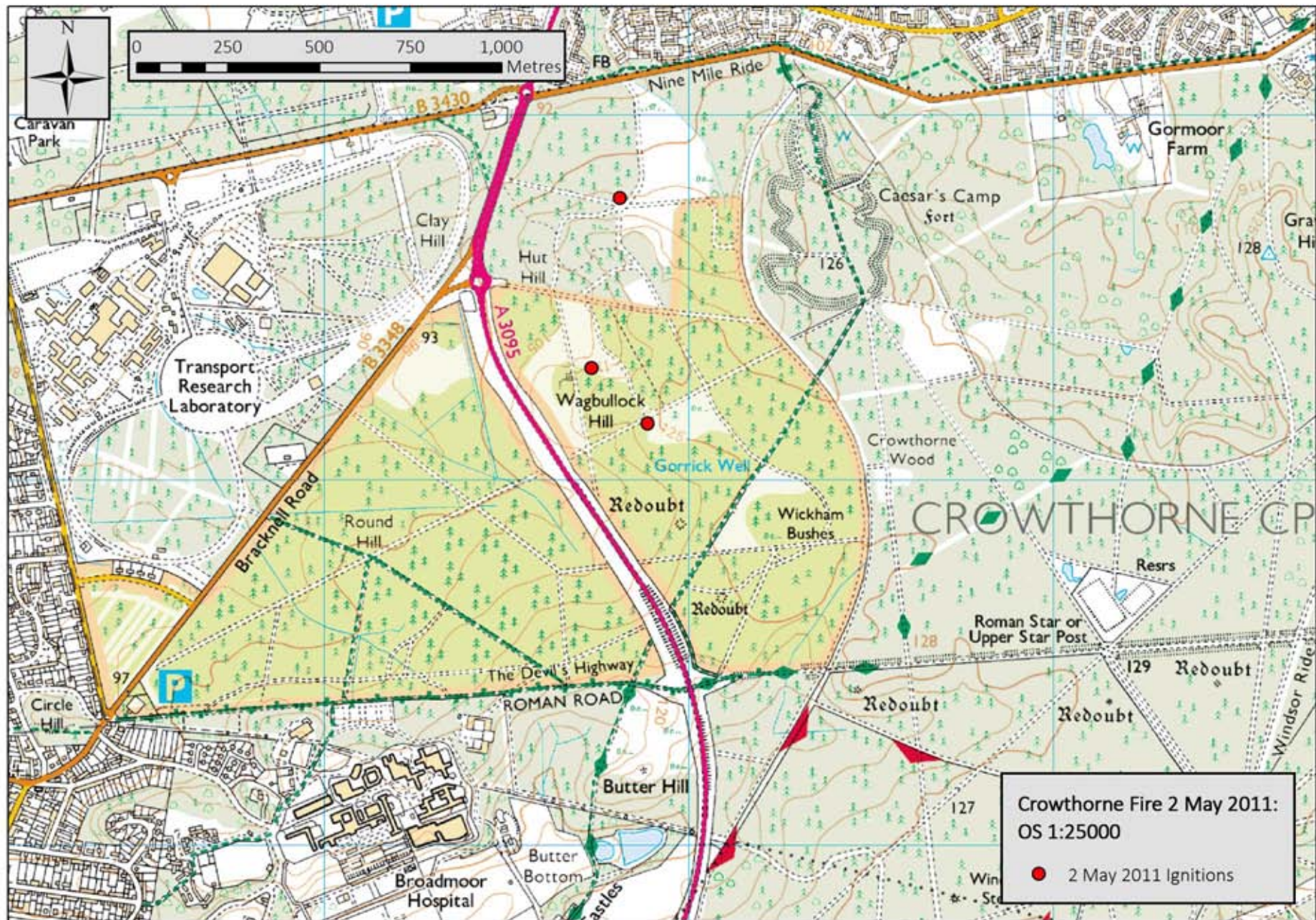
0 250 500 750 1,000  
Metres



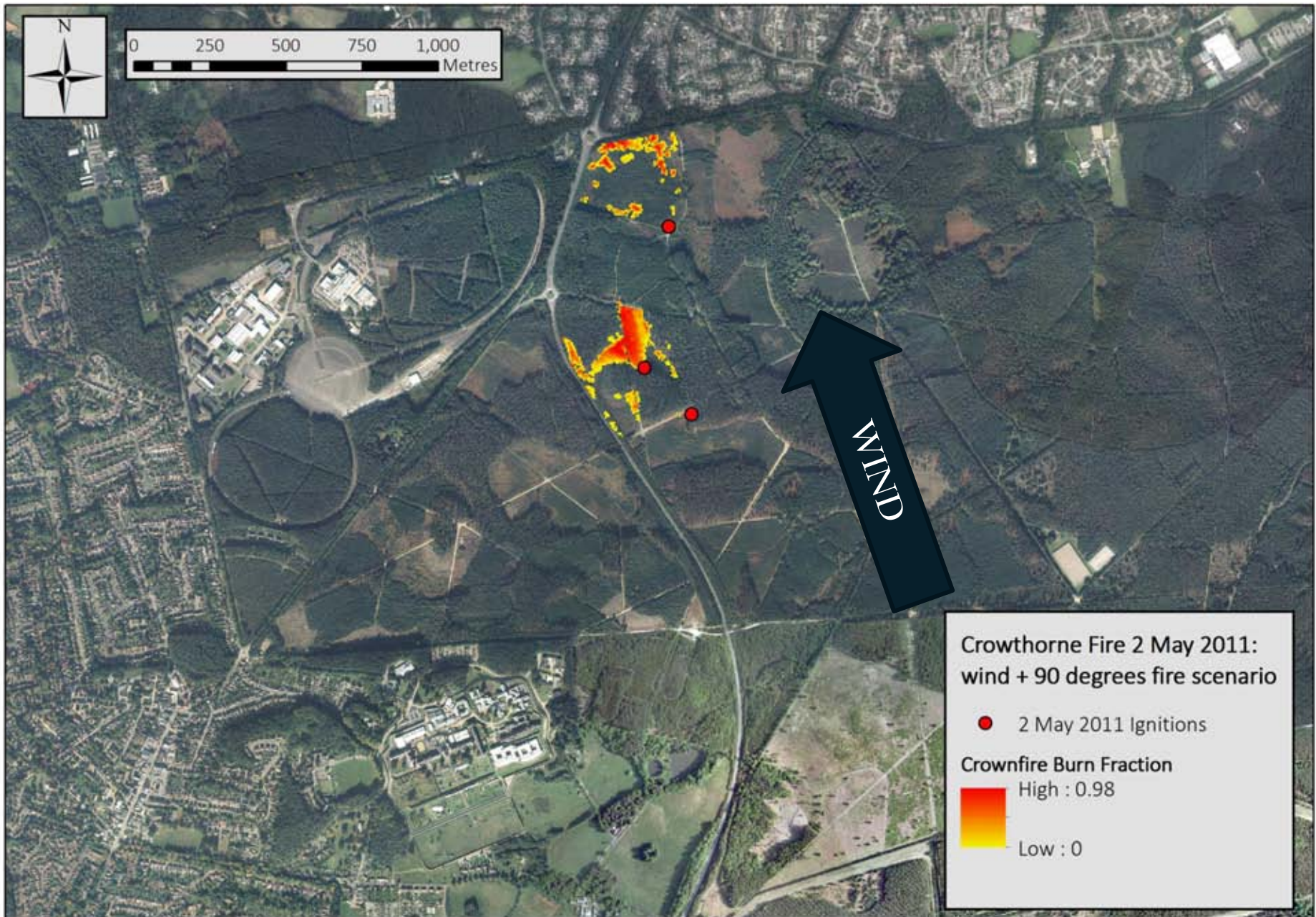
**Crowthorne Fire 2 May 2011:  
simulated fire scenario**

- 2 May 2011 Ignitions
- Simulation: Wind + 90 degrees
- FCE Fire Extent Map

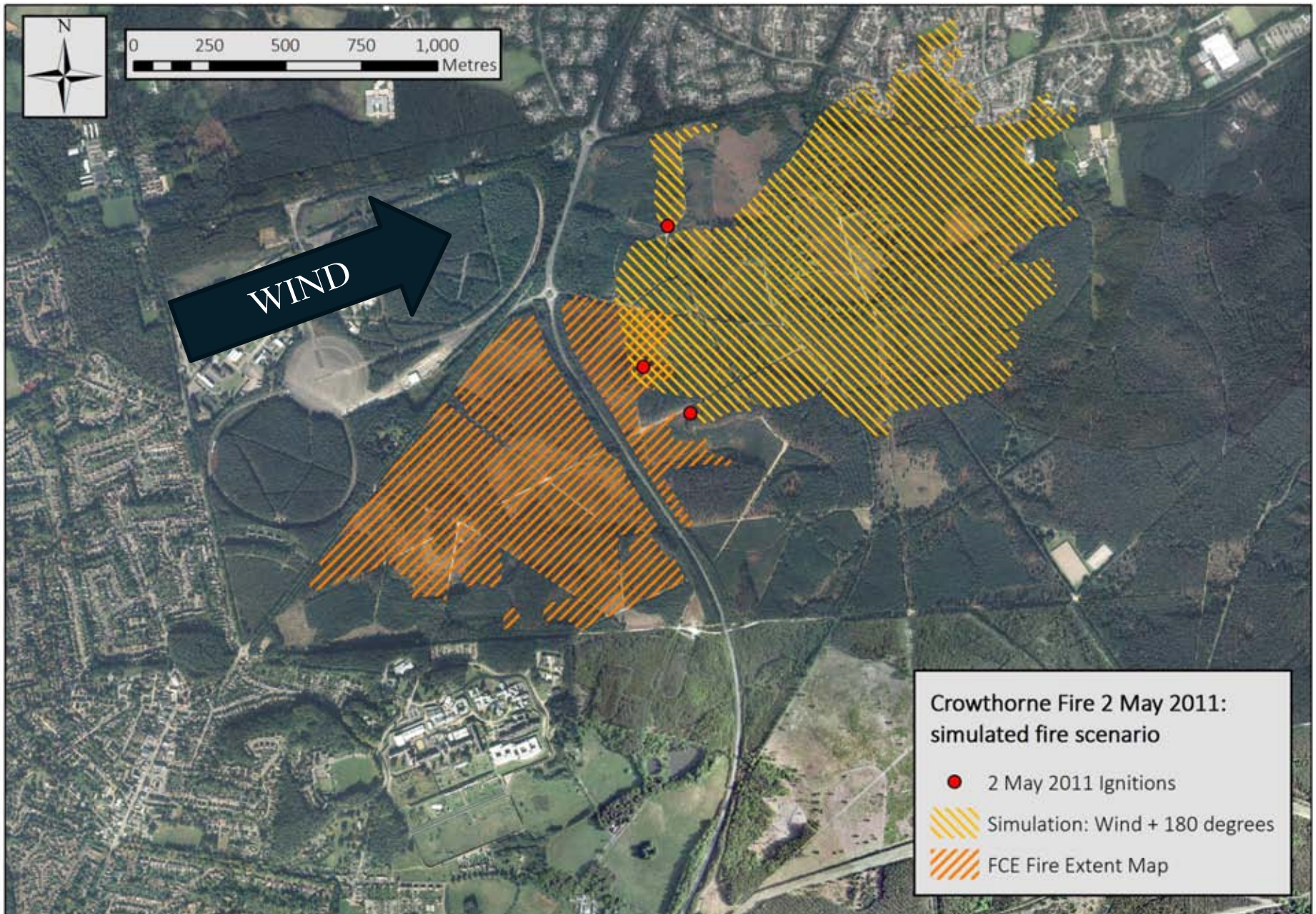




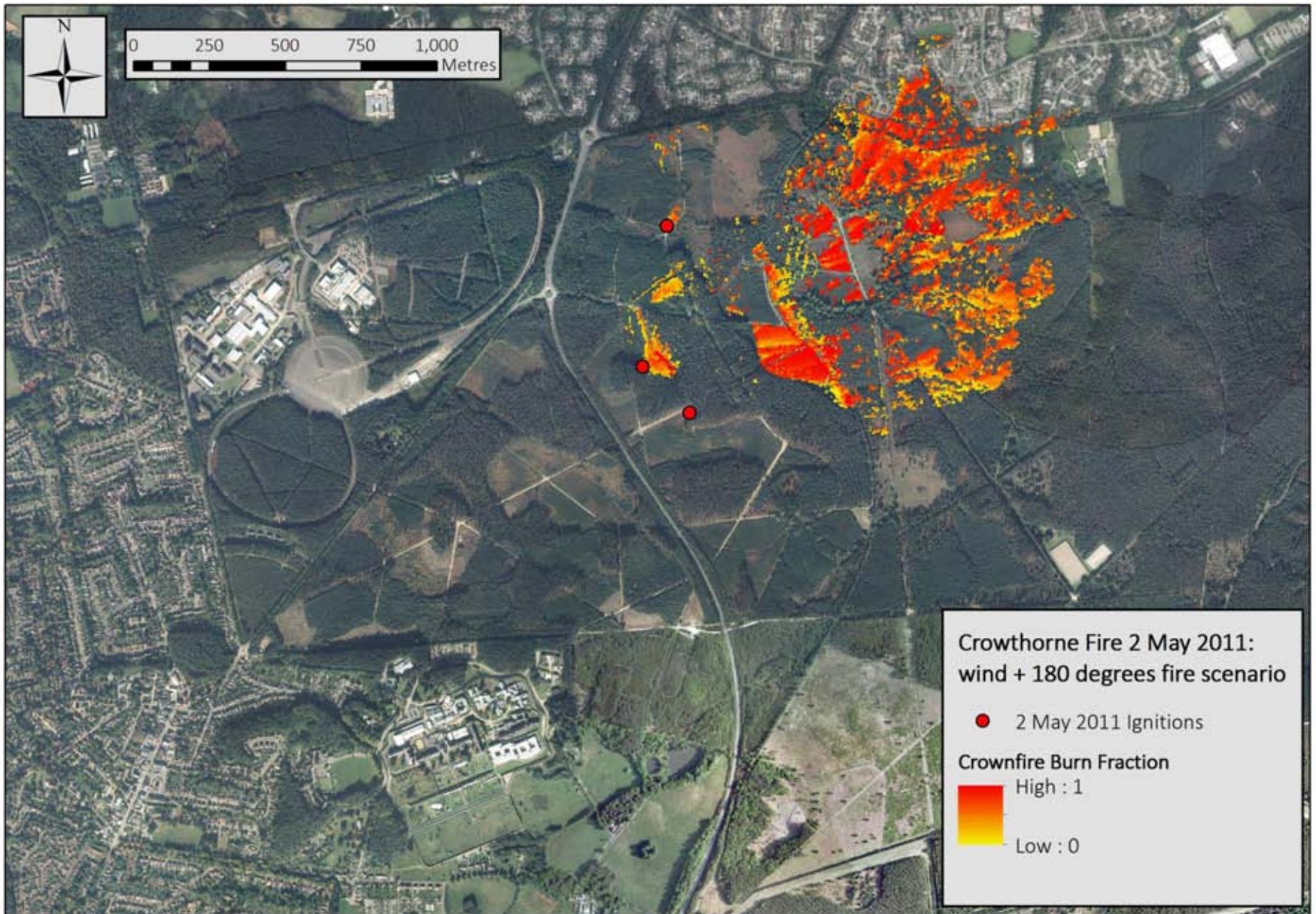




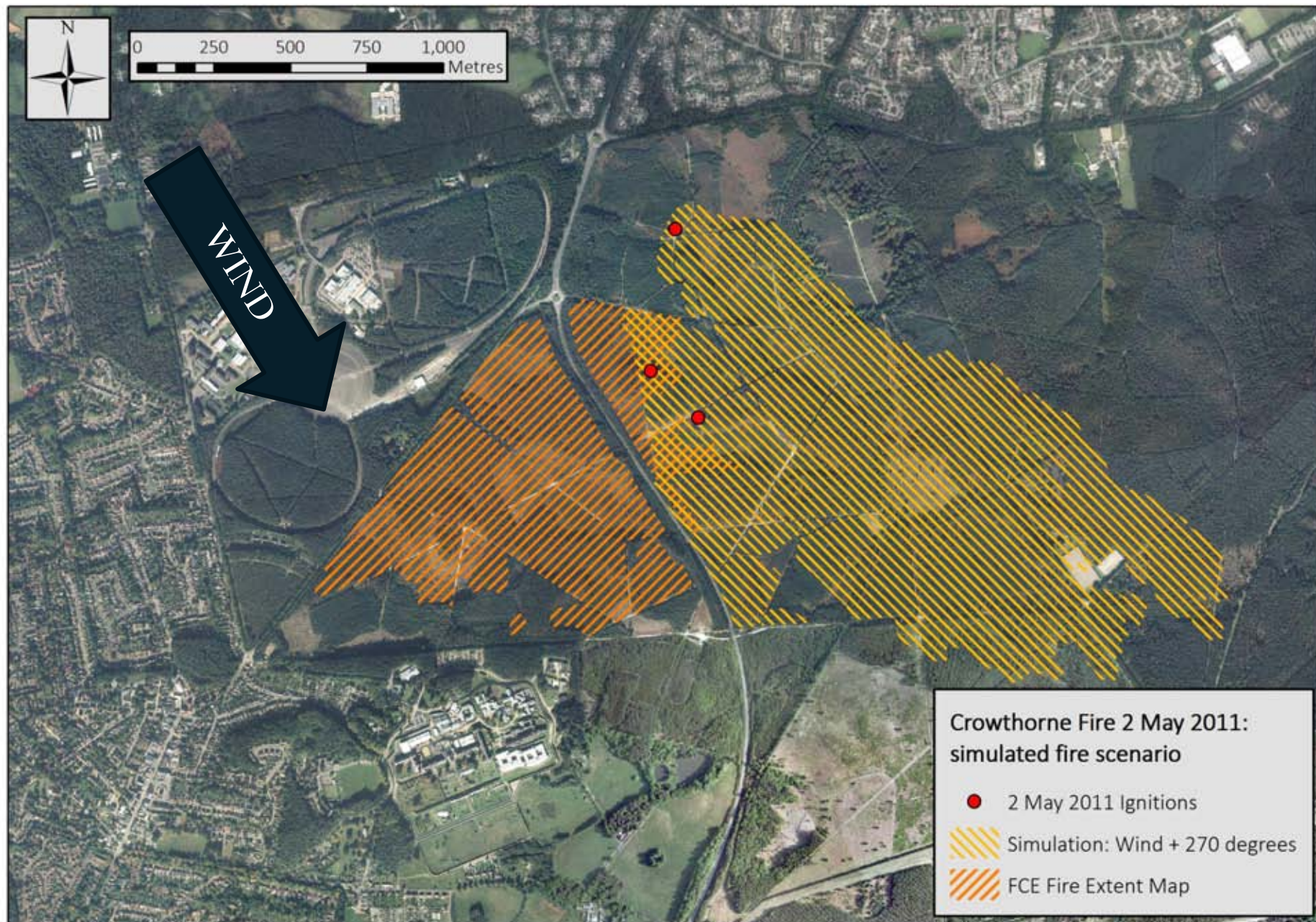
















0 250 500 750 1,000  
Metres

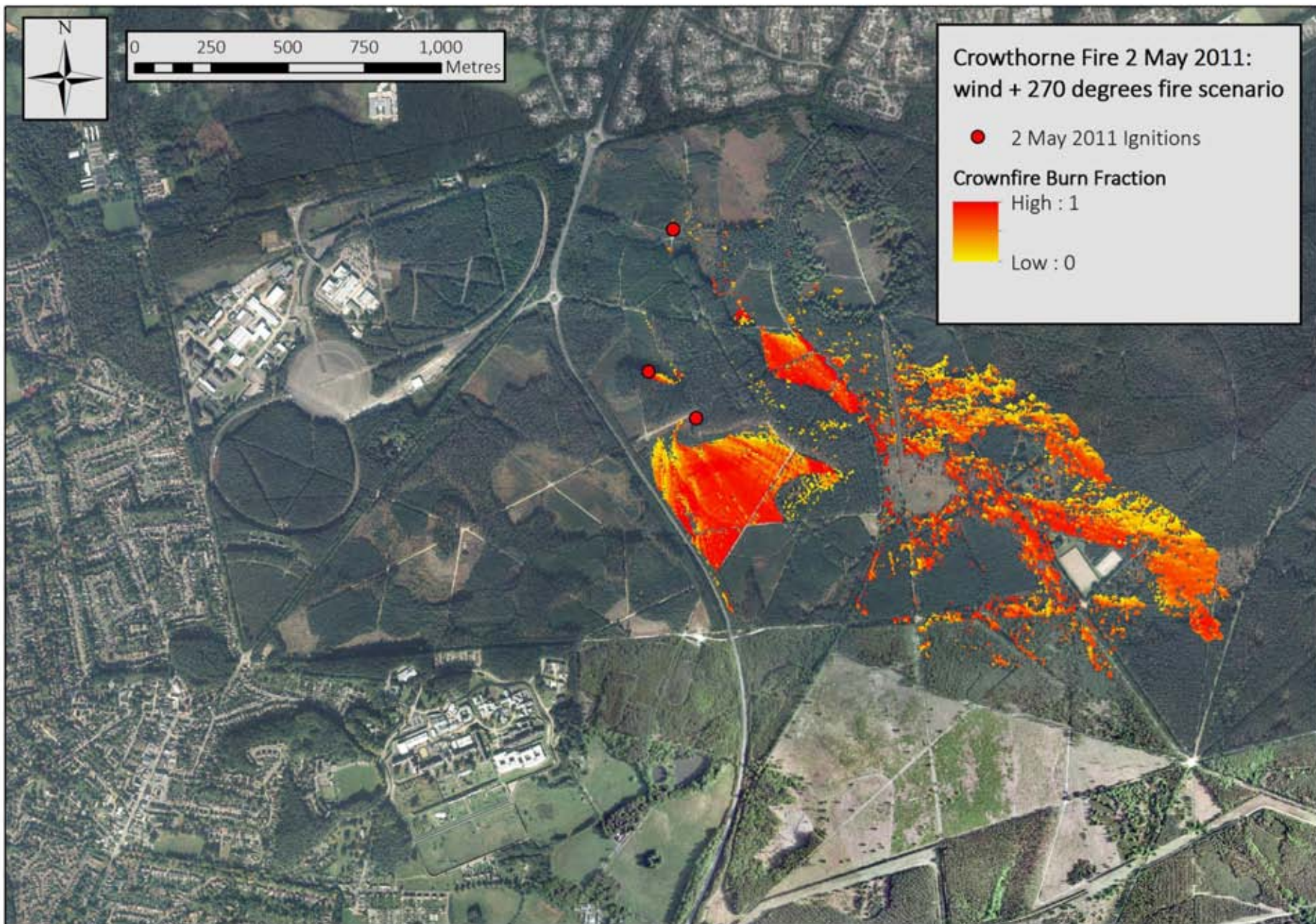
# Crowthorne Fire 2 May 2011: wind + 270 degrees fire scenario

● 2 May 2011 Ignitions

Crownfire Burn Fraction

High : 1

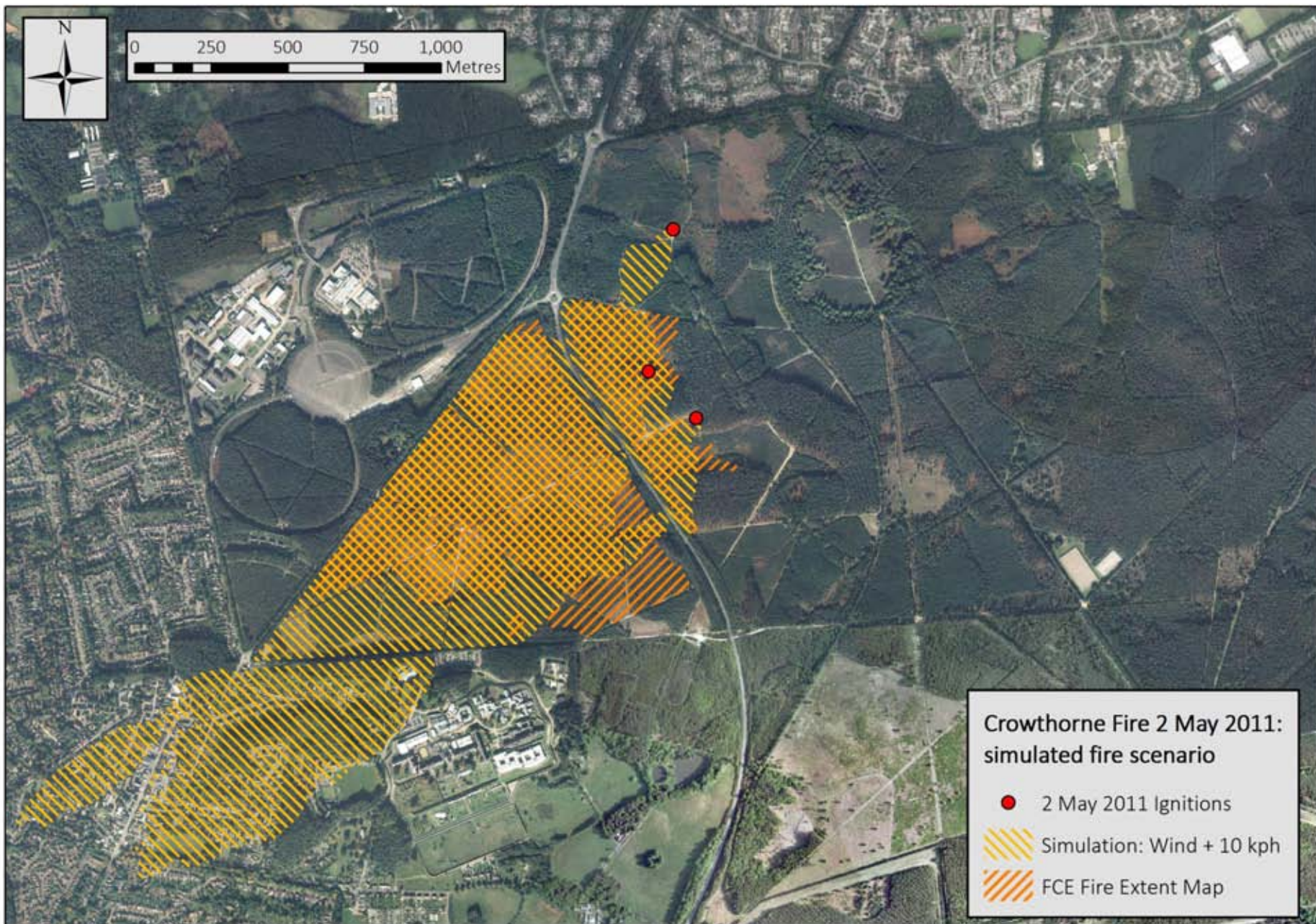
Low : 0



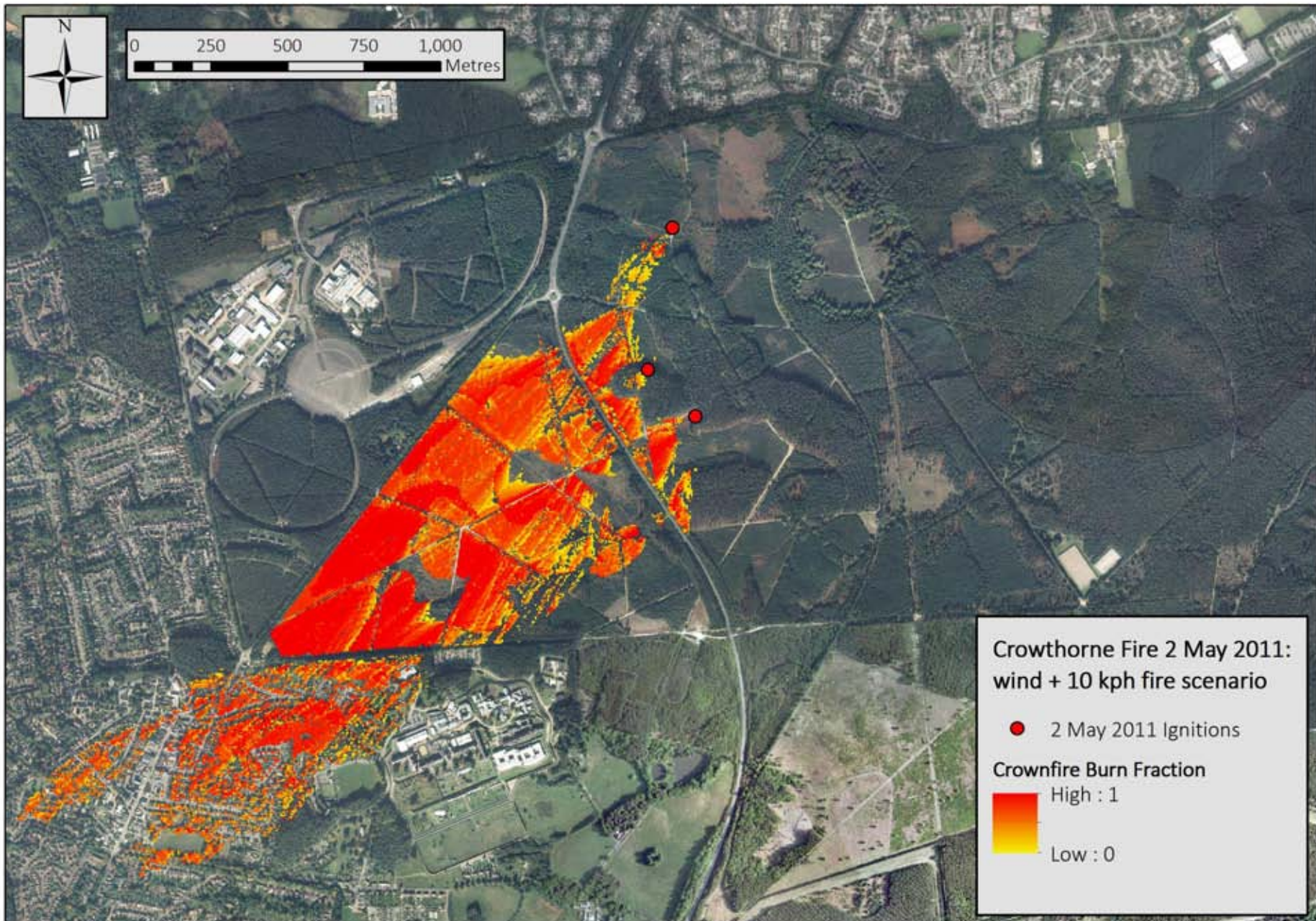




0 250 500 750 1,000  
Metres

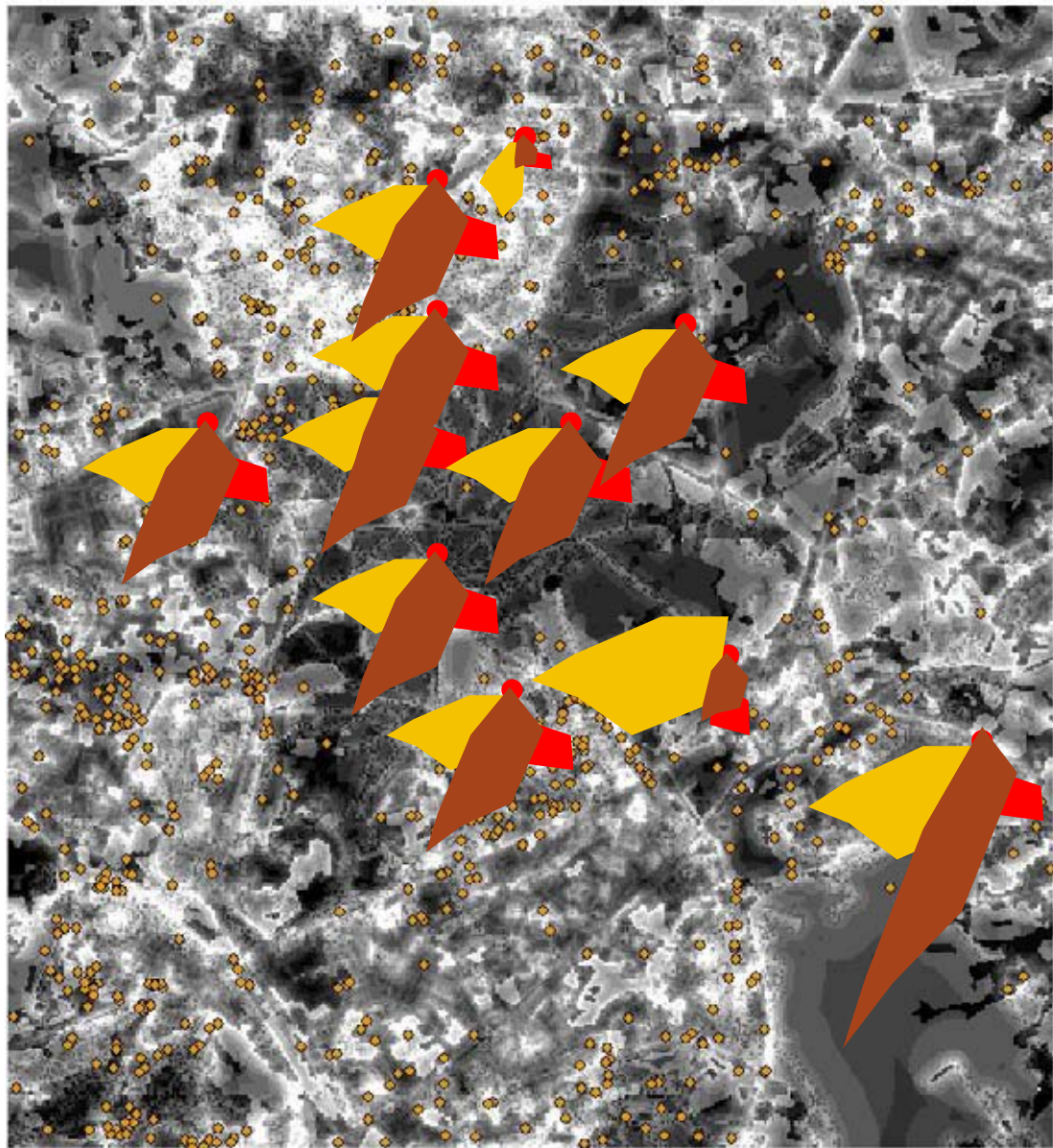








# TOWARDS “ENSEMBLE” FIRE SPREAD MODELLING



## Risk of ignition

### Weighting:

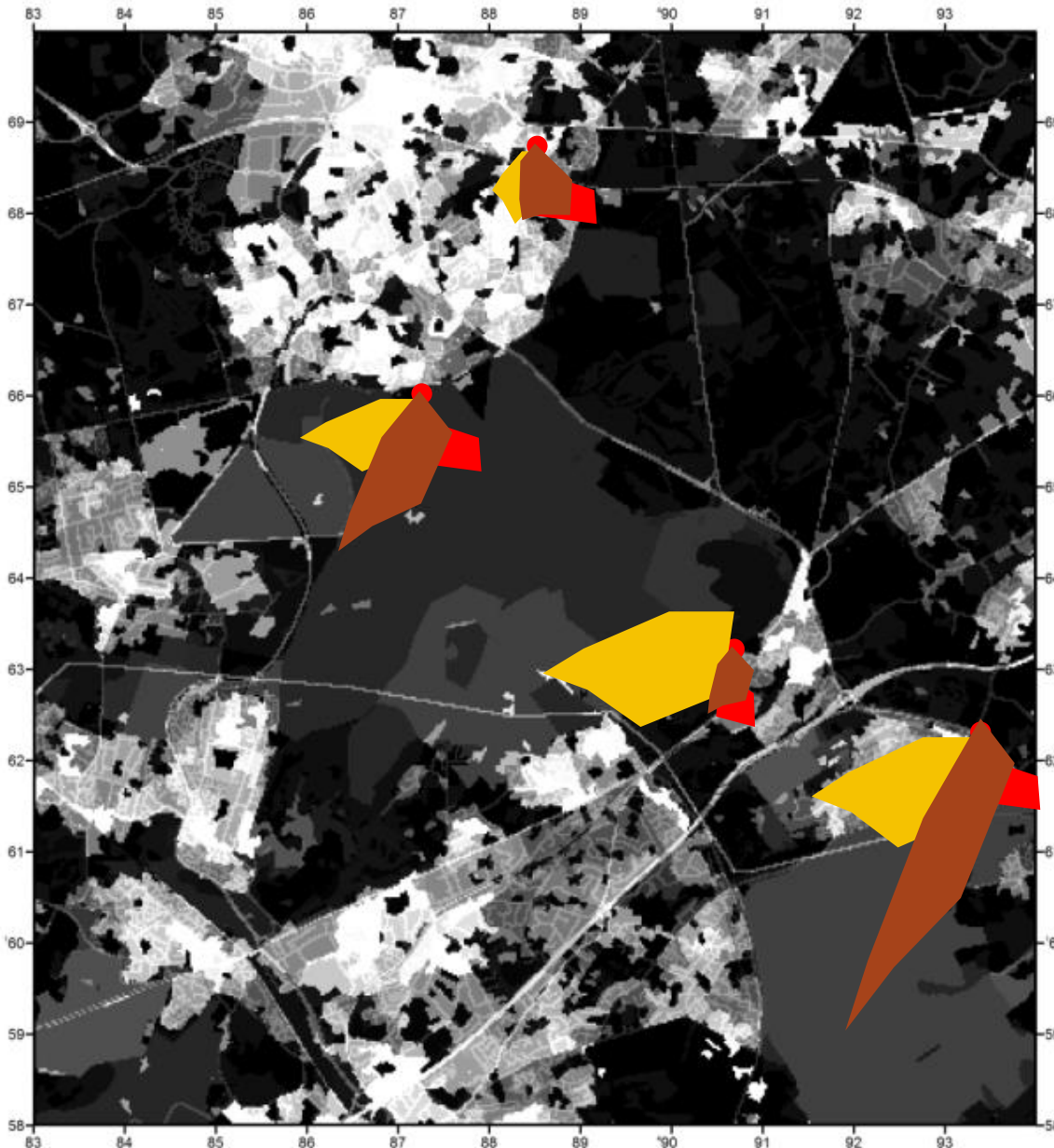
Land cover (expert judgement): 5  
proximity to built-up areas: 3.5  
Proximity to foot access routes: 3  
Proximity to car access routes: 3  
Access land: 3  
Population density: 3  
Infrastructure and installations: 1



**Average fire size**  
**Average fire intensity**  
**Worst case scenario?**



# TOWARDS “ENSEMBLE” FIRE SPREAD MODELLING



## Values at Risk

Weighted layers:

Health and well-being: 5  
Property and infrastructure: 3  
Ecosystem services: 1



**Average fire cost**  
**Worst case scenario?**





**POSTER: [tinyurl.com/hewittsmith2014](http://tinyurl.com/hewittsmith2014)**

# Assessing trade-offs between wildfire reduction strategies and stakeholder values in the Eastern Mourne Mountains

Charlotte Hewitt &amp; Thomas E L Smith

*King's College London, Earth & Environmental Dynamics Research Group, Department of Geography, Strand, London, WC2R 2LS*

**STUDY AIM:**

To recommend zones of the Eastern Mourne Mountains where effective fuel load management may be implemented without detrimentally affecting local stakeholders.



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LONDON

### I. Wildfires in the Eastern Mourne Mountains



**Figure 2** (for right): Wildlife in the Eastern Miquelon Mountains in April 2021

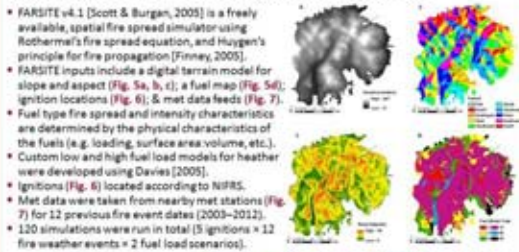
- The **Moore Mountains Area of Outstanding Natural Beauty (Fig. 1)** is a region of economic importance with a range of stakeholders including farmers, conservationists, utility providers, and recreational groups (**Table 1**).
- In Spring 2011, wildfires in the EMM (**Fig. 2**) were described as the “single biggest incidence in the Moors in recent memory” (Climate NI, 2013).
- This was not an isolated incident; wildfires in the Eastern Moore Mountains (EMMs) were reported in 2008 and 2009, including 4 or more pumps between 2008 and 2013 (**Fig. 3**).
- A group of wildfire firefighting experts were commissioned to recommend wildfire hazard reduction strategies (MHT, 2013); their report recommended prescribed burning, enhanced grazing, and mechanical cutting for fuel reduction, and divided the landscape into management sectors according to likely fire spread patterns (**Fig. 4**).



**Figure 3** Distribution of wildlife calls received by Northern Ireland Fire & Rescue Service regarding UK 2+ (00 3+ (00 8+ (00 9 or more jumps.

## II. FARSITE wildfire spread modelling

- FARSITE v4.1 [Scott & Burgan, 2005] is a freely available, spatial fire spread simulator using Rothermel's fire spread equation, and Hugen's principle for fire propagation [Finney, 2005].
- FARSITE inputs include a digital terrain model for slope and aspect (Fig. 5a, b, c); a fuel map (Fig. 5d); ignition locations (Fig. 6); & met data feeds (Fig. 7).
- Fuel type fire spread and intensity characteristics are determined by the physical characteristics of the fuels (e.g. loading, surface area volume, etc.).
- Custom low and high fuel load models for heather were developed and used (Fig. 8).
- Ignitions (Fig. 6) loaded according to NIRS.
- Met data were taken from nearby met stations (Fig. 7) for 12 previous fire event dates (2003–2012).
- 120 simulations were run in total (5 ignitions  $\times$  12 fire weather events  $\times$  2 fuel load scenarios).



**Figure 3** (top) IRRISTE spatial domain: (A) SRTM, (B) Aspect, (C) Slopes, (D) Fuel map, where: 0 = low fuel density, 1 = high fuel density.

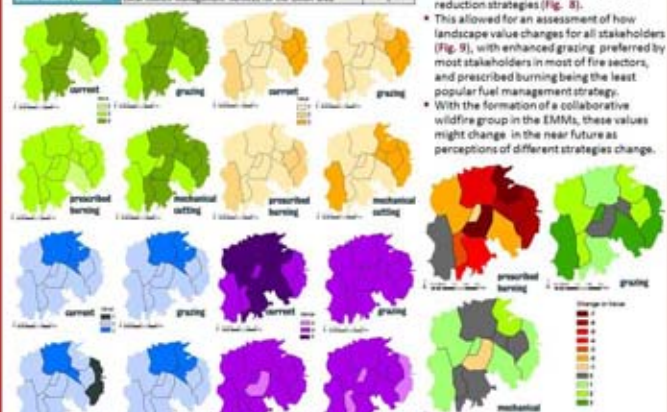


### III. Managing wildfire risk & stakeholder values

Organisation	Key activities in the 2000s	Participants
Swedish Youth	Management of ACRS, leading erosion and habitat restoration projects, communication with public & farmers and owners of most of the ACRS, organising the first	3
Spain NI	A public policy promoting, and facilitating outdoor sports e.g. mountain biking, hill walking, rock climbing	5
Cooperating, Ireland	Supports and represents NIAR initiatives and children	6
Wales	Organises full training courses and interesting events for member groups	6
Cooperating, Ireland	Mountain Biking groups, Orienteering and Thoroughbred Races, & the AG Agricultural Processors Association	3
UK Forest Services	Ownership of forests within the Exmoor National Park, including Tollymore, Anliffing and Dunham	3
NI Waters	Ownership of all land within the Binnion Wall, catchment areas feeding into Villars Valley and Coarres reservoirs	3
Denmark National Council	Ownership of the Binnion Wall	3

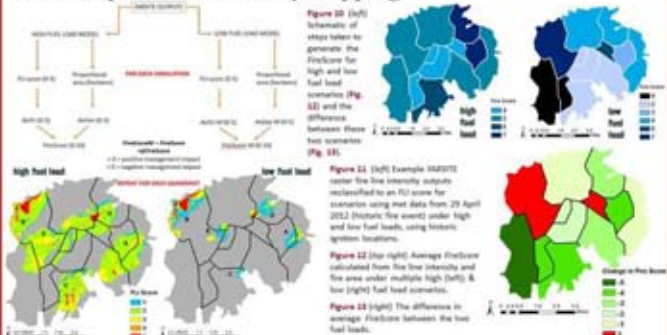
**Table 2.** (left) List of stakeholders involved with this study and a summary of their main activities in the 1990s.

- Stakeholder engagement is recognised as important for effective land and resource management [JMA, 2005].
- This study engages with relevant stakeholders (Table 1) to explore any trade-offs between proposed fuel reduction strategies and landscape value.
- The EMMA is a collaborative framework and asked to value the EMMA fire services under their current management, and under the three different proposed fuel reduction strategies (Fig. 8).
- This allowed for an assessment of how landscape value changes for all stakeholders (Fig. 9), with enhanced grazing preferred by most stakeholders in most of five sectors, and prescribed burning being the least popular landscape management strategy.
- With the formation of a collaborative wildfire group in the EMMA, these values might change in the near future as perceptions of different strategies change.



**Figure 8** Average stakeholder values for the (green) NGOs (orange) farmers; (blue) government; and (purple) recreational EMAs stakeholders under different land management strategies.

#### IV. Fire spread and severity mapping

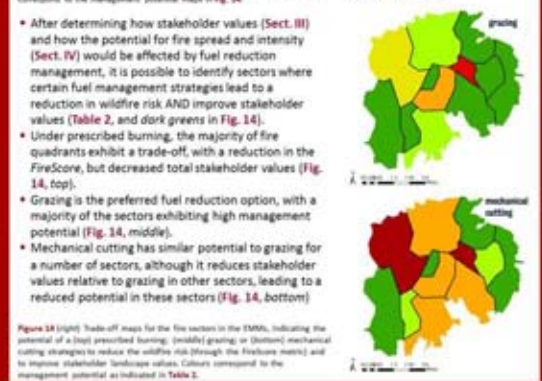


Average fireline intensity (0 to 100) and change in fireline intensity (-5 to 5) are shown on the map. The map includes a scale bar from 0 to 10 km and a north arrow.

## V. Risk reduction & stakeholder value trade-offs

<i>A/B</i> scores classification	<i>S2M</i> classification	Management Potential	Explanation
<0	>0	High	Real benefit
<0	0	Moderate (P)	<i>A/B</i> scores improved
<0	<0	Low (P)	
<0	<0	Low (S)	
>0	>0	Low (S)	<i>S2M</i> improved, negative <i>S2P</i> impact
>0	>0	Low (P)	
>0	>0	None (P) and (S)	Small negative impact
>0	>0	None (P)	negative <i>A2M</i> impact, no <i>S2P</i> impact
>0	>0	None (S)	negative <i>S2P</i> , no <i>A2M</i> impact

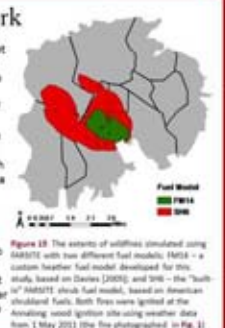
**Table 2** A summary of the conditional statements used to assess management potential for each sector under each of the land management strategies, where  $SH$  = shareholder uptake, and  $FL$  = firefree (see Fig. 10 & Fig. 11). The new colours conveyed to the management potential maps in Fig. 14



**Figure 3A** [right] Trade-off maps for the five sectors in the TMMs, indicating the potential of a (top) prescribed burning; (middle) grazing; or (bottom) mechanical cutting strategies to reduce the wildfire risk (through the FireScore metric) and to improve stakeholder landscape values. Cultures correspond to the management potential as indicated in Table 2.

## VI. Limitations & future work

- Economic costs of the fuel reduction strategies were not factored in to the stakeholder valuations. This could dramatically alter management potential and should be considered in future work.
- Perception of value of different options might change if stakeholders were to consider economic costs, and might change over time under a more collaborative fire management (e.g. prescribed burning was shown to be less damaging than current perceptions). A comparison with future stakeholders after a number of years with a fire group should be conducted.
- Proper evaluation of FARSITE for simulating rate-of-spread in heather fuels needs to be conducted. Fig. 15 shows the difference in fire spread between the customised heather fuel model and the 'built-in' shrub model for the 1 May 2011 fire (Fig. 3). The fire perimeter for the scenario using the built-in model best represents the actual fire that occurred that day. Further observations of rate-of-spread need to be conducted to help improve model evaluation.



**Figure 15** The extent of wildfires simulated using AARSITE with two different fuel models: FM12 - a custom heather fuel model developed for this study, based on Davies (2005); and FM6 - the 'South-Is' AARSITE shrub fuel model, based on American shrubland Fuels. Both fires were ignited at the Araratwood wood ignition site using weather data from 1 May 2001 (the fire photographed in Fig. 11).

## References

**Shirley Stueben** received her PhD from the University of Minnesota, where she was a member of the Phi Kappa Phi Honor Society. She is currently an associate professor of psychology at the University of Minnesota, where she teaches and supervises graduate students. Her research interests include the development of self-regulation and the role of the family in the development of self-regulation. She is currently co-authoring a book on the development of self-regulation with her husband, Dr. David Stueben, University of Minnesota.

### Acknowledgements

We are most grateful to the Māori Heritage Trust and in particular Mātāwhiri Smith, who was generous with his time and resources during and prior to the stakeholder interviews in Northern Ireland. We thank all the participant stakeholders. Funding for this work came from a JISC Knowledge Exchange Project no. J0806123 and ECHO project F0805040.






# QUESTIONS?

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# NERC

## SCIENCE OF THE ENVIRONMENT



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Earth Observation**

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# FIREfficient

Operational tools for improving efficiency in wildfire risk reduction in EU landscapes



This project is co-funded by  
the European Union

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