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# Validation of the AUSTRALIS Wildfire Simulator Using a Large-Scale Historical Fire

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## AUSTRALIS Research Programme

### ARC Linkage Project:

Funding from ARC, FESA and Landgate

### Digital Regions Initiative Aurora Project:

Funding from Commonwealth Dept. of Broadband, Communications and the Digital Economy.

Collaboration between Landgate, FESA and UWA Computer Science

### Thanks to:

FESA, Landgate, DEC and Bushfire CRC (prior funding)

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## AUSTRALIS Wildfire Simulator

- predicts bushfire spread using fuel, weather and rate-of-spread data
- allows the location of future fire perimeters to be communicated via email, SMS and maps on web enabled mobile devices e.g. the AURORA Early Warning System
- rapidly generates detailed spread maps fully automatically

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## Wildfire Simulator may be used for:

- response management – spread prediction of actual live fires, issuing alerts and maps with future fire locations
- planning – examination of effectiveness of fuel reduction and risk assessment strategies
- training – running training scenarios for incident controllers: e.g. multiple live fires in high fire danger index conditions

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## AURORA System Overview

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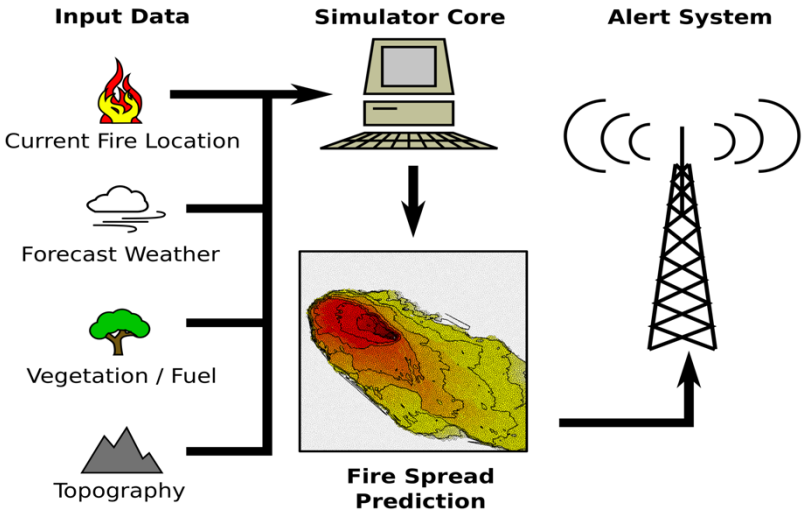


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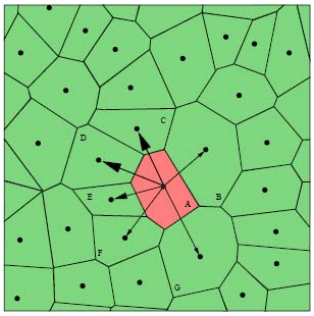
## Fire Spread by Propagation Delay

- each cell has approximately 10 neighbours
- rate of spread calculated using fuel type, moisture, wind speed and direction
- distance and direction to each neighbour determines ignition time of neighbour from most recently ignited cell



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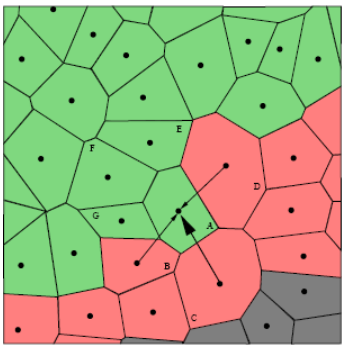
## Spread over Landscape with wind from SE

- each cell in one of three states: *unburnt*, *burning* or *burnt*
- ignition changes the state of *unburnt* cells to *burning*
- when cell ignited, ignition of each of its unburnt neighbours is calculated and scheduled
- burnt cells cannot be re-ignited

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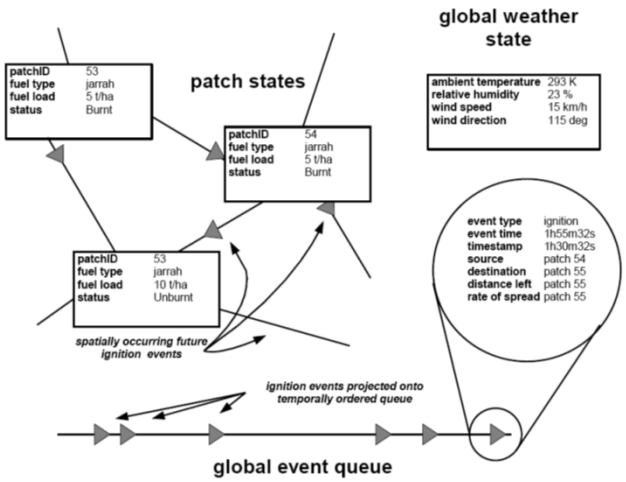
## Discrete Event Simulation

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## AUSTRALIS Simulator: validation using historical fires

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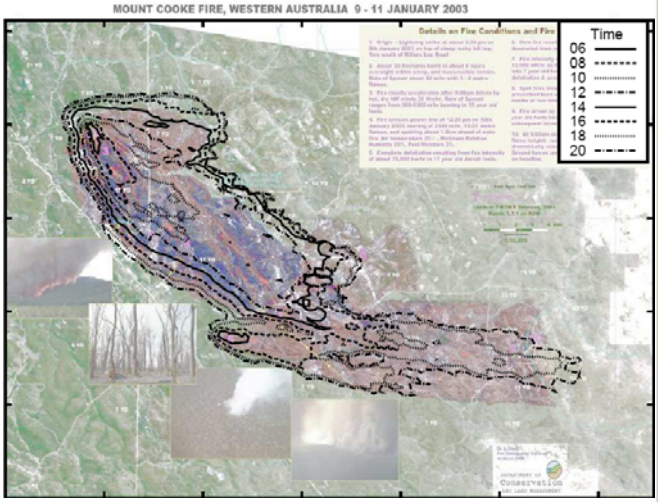
Mt Cooke fire simulation with fuel ages resulting from prescribed burning history

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## Same scenario with no prior fuel reduction

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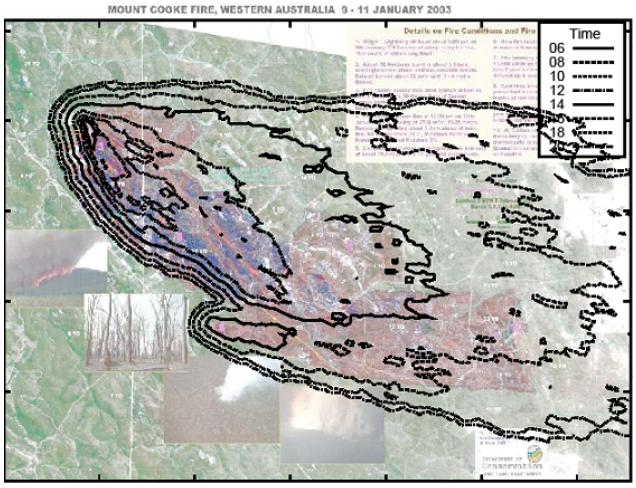
Mt Cooke fire simulation assuming all areas have 15 year old fuel

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## Data sets required prior to operation

- topographic maps
- vegetation maps
- fuel load maps
- rate-of-spread model for each vegetation type
- current and forecast weather – downloaded automatically from the Bureau of Meteorology
- ignition locations and time of ignition (or current fire perimeter) – entered manually into GIS

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## Fast simulation permits:

- new predictions rapidly generated if location of fire perimeter updated or weather forecast changes
- fire managers able to run what if simulations for alternative weather scenarios e.g. stronger winds or timing of change in wind direction (passage of a front)
- simulations at 10km x 10km at 100m resolution (~7000 cells) runs in ~30s

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## Challenges

- accurate forecast weather for fireground location
- accuracy of fuel mapping; fuel ages, load and type
- Fire Behaviour Models in extreme conditions; may under-predict rates of spread
- availability of accurate data on current fire location
- validation of simulation technology

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## Fire Behaviour Models

- Existing Fire Behaviour Models used to predict rates of fire spread from cell to cell based on weather and fuel inputs
- Selection of appropriate FBM based on vegetation type
- Choice may be constrained by input data availability
  - e.g. Project Vesta fuel hazard score maps
- Problem : FBMs may under-predict rates of spread in **extreme** conditions
  - ARC project with FESA and Landgate uses remote sensing and historical fire data to address this

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## Simulation Validation

- Validation is necessary to:
  - test simulation algorithms and software
  - improve Fire Behaviour Models
  - increase confidence in simulator results
  - Validate by simulating as many historical fires as possible where good data is available
  - Challenge : sourcing high quality data from previous extreme fires
- Have validated with “live” FESA data last fire season

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## Australis Simulator Demonstration

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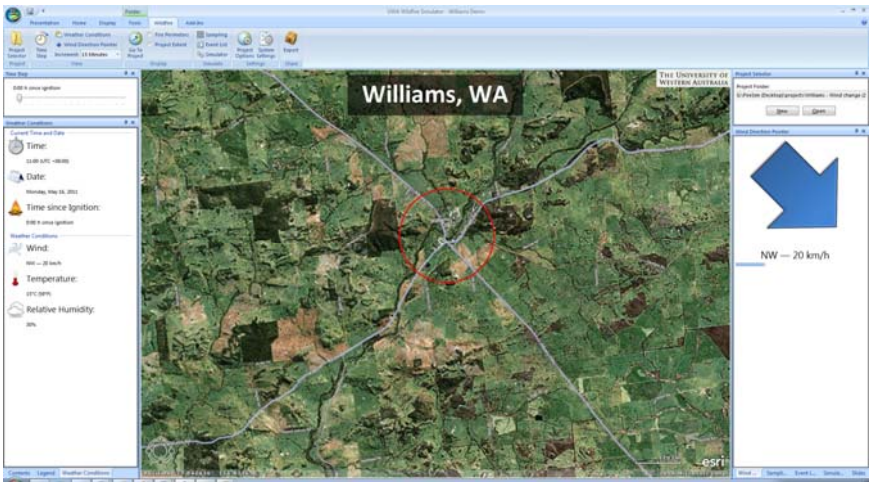


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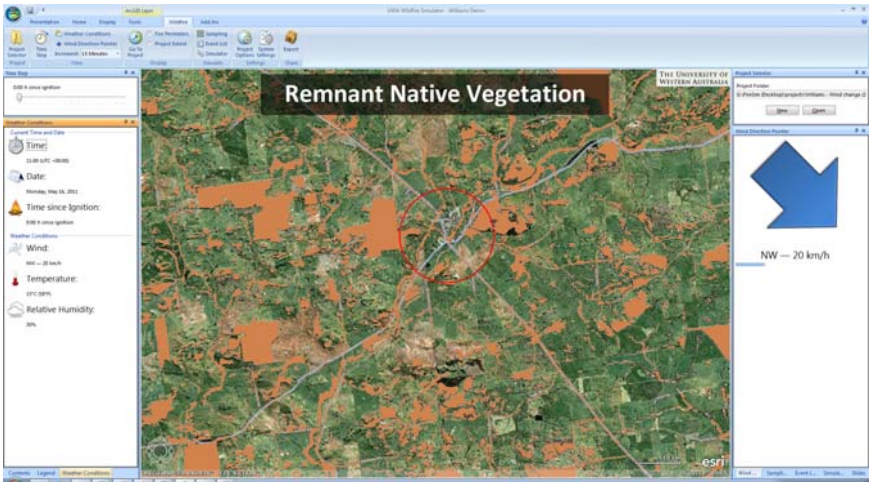


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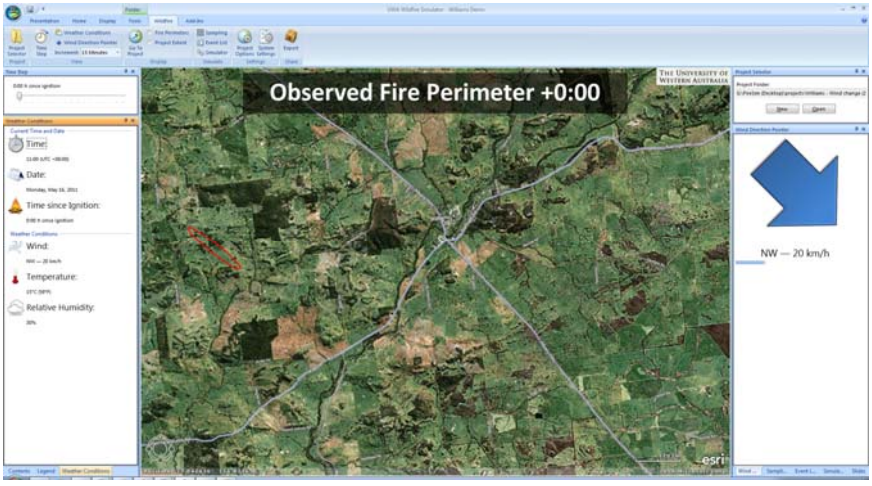


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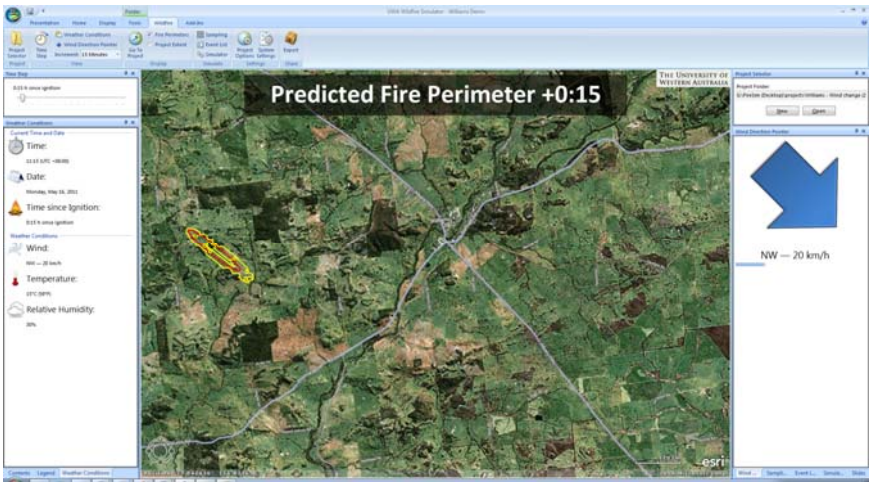


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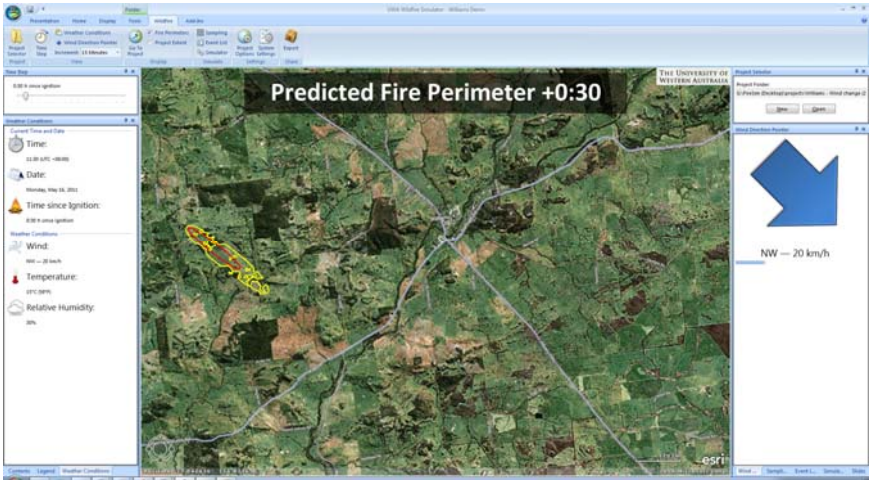


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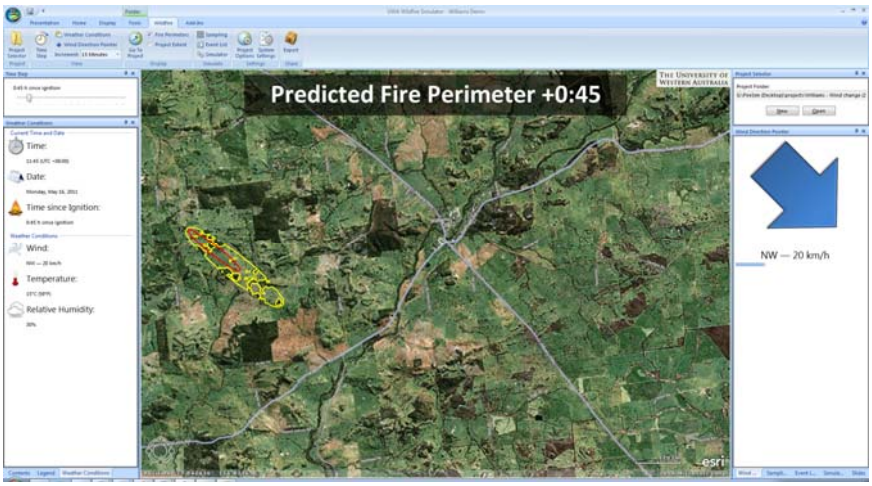


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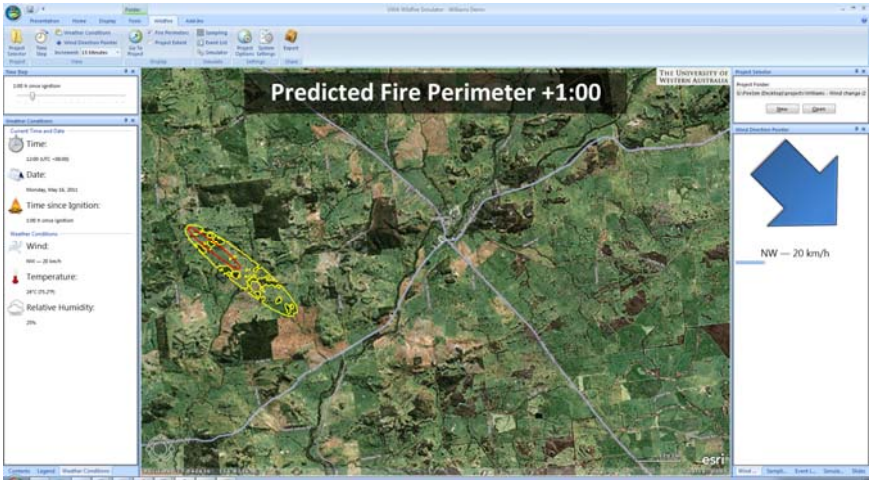


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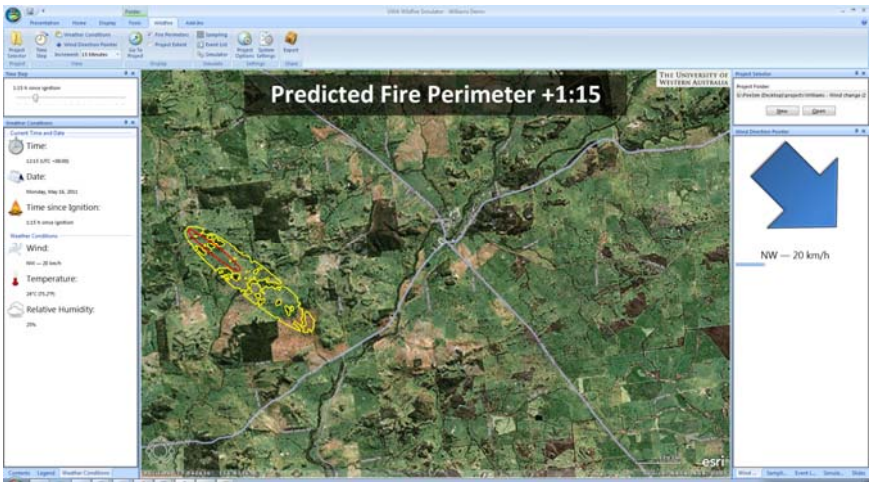


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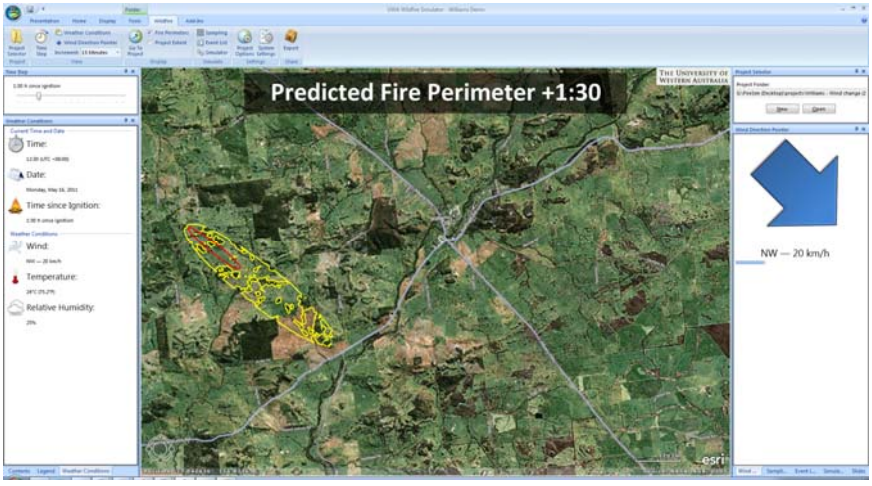


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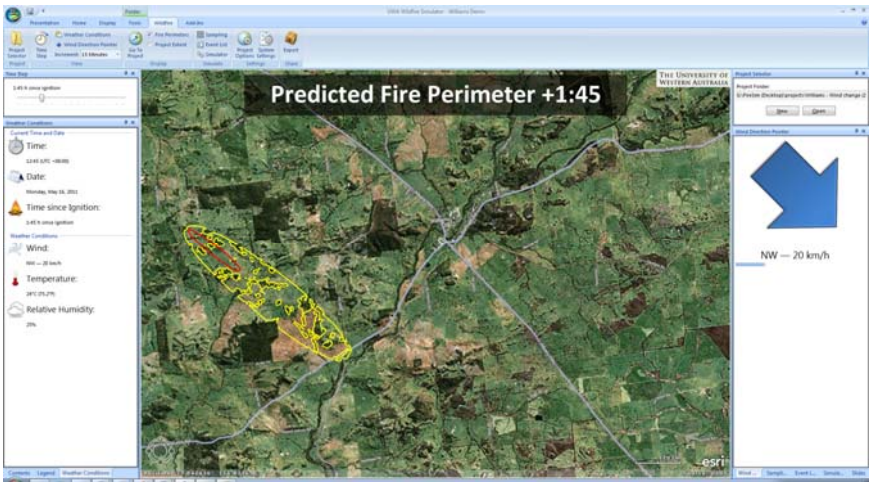


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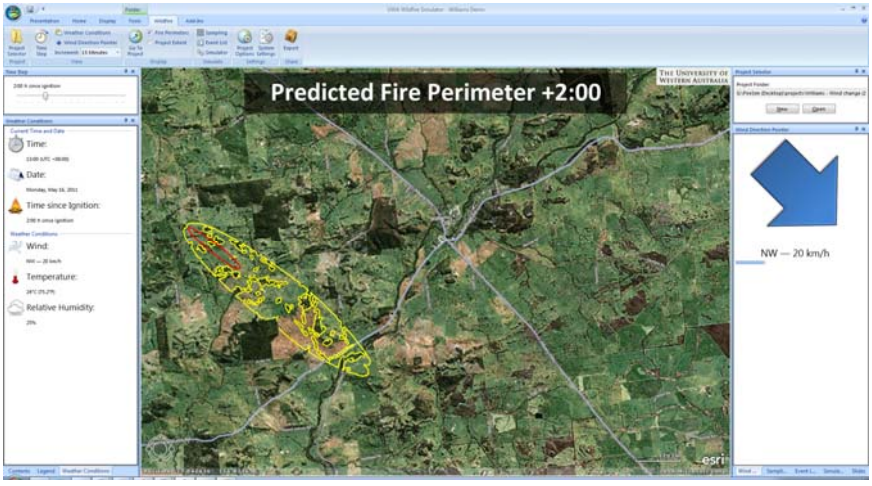


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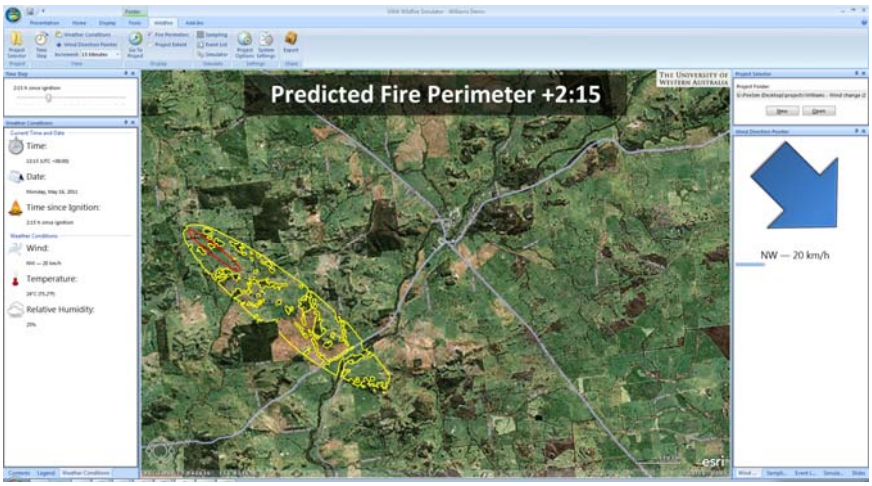


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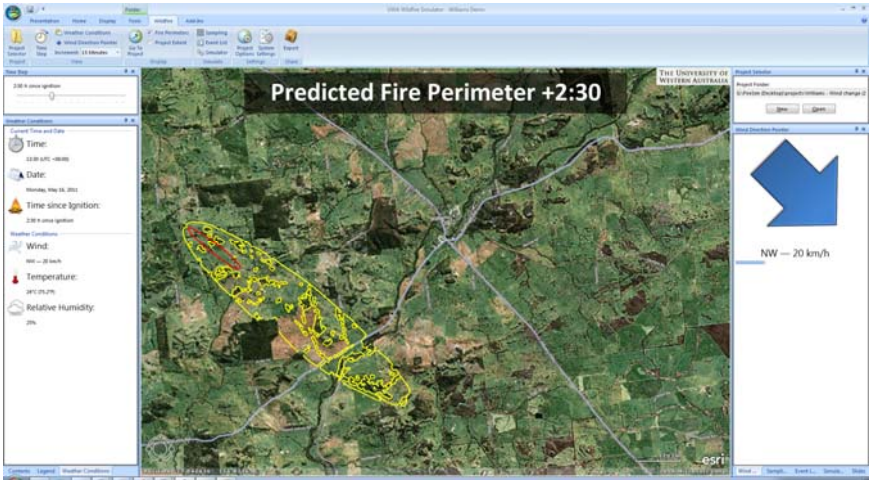


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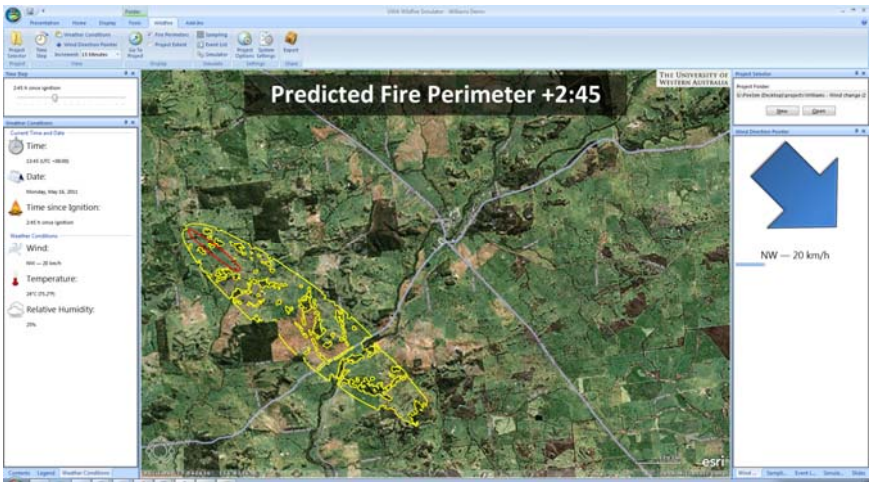


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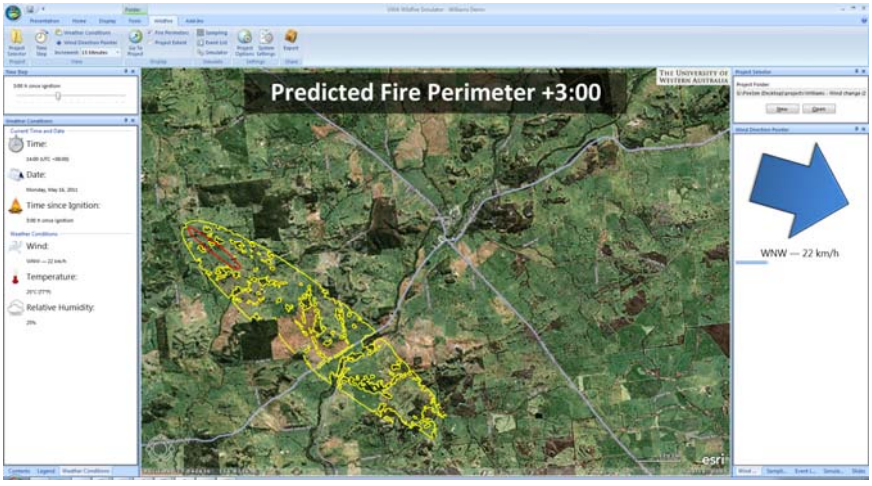


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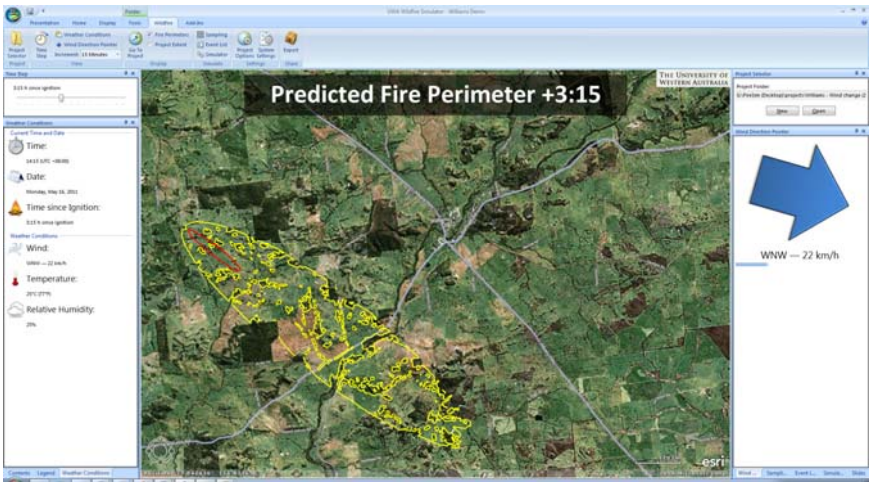


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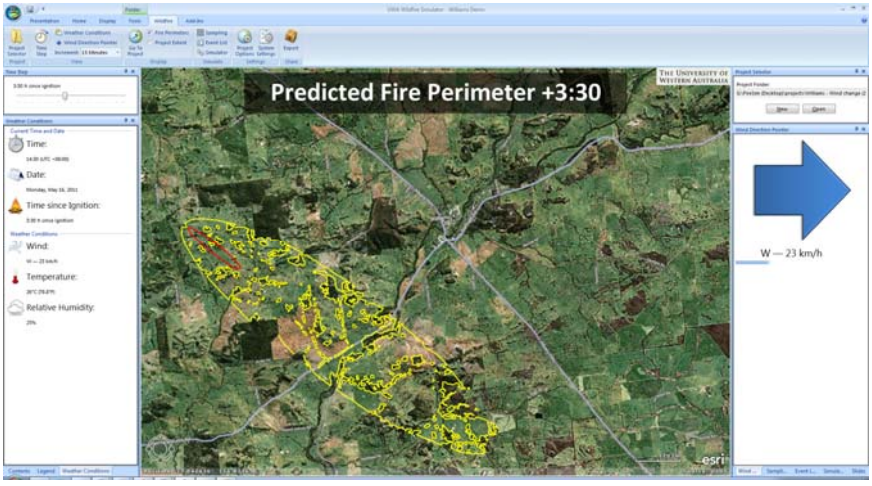


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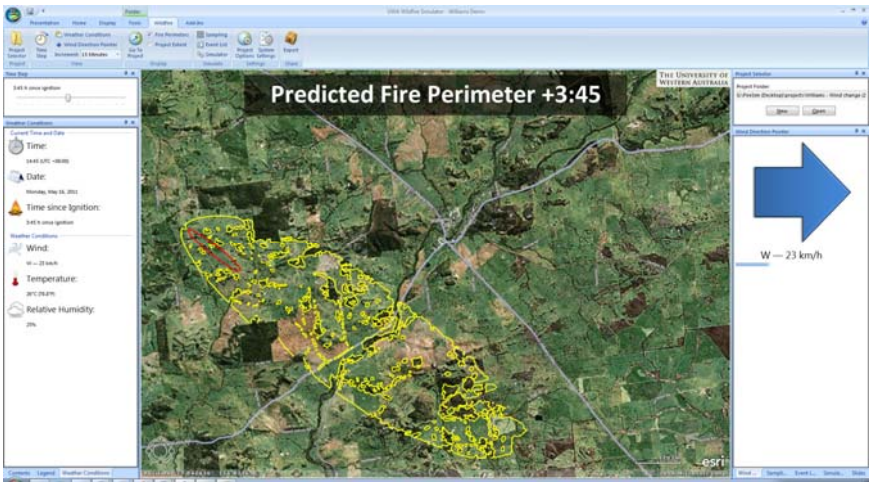


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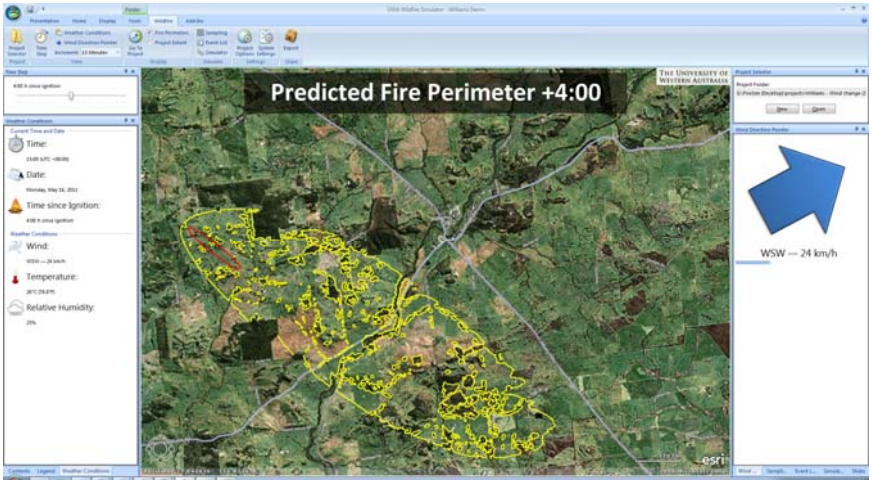


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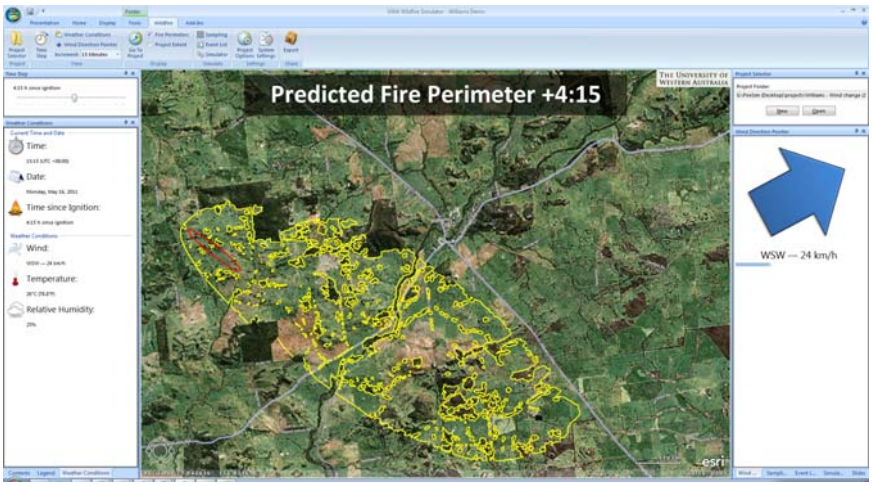


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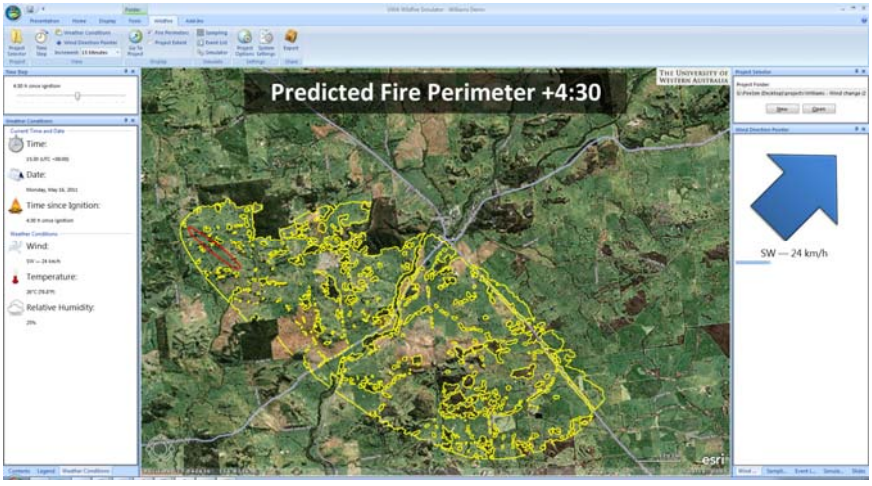


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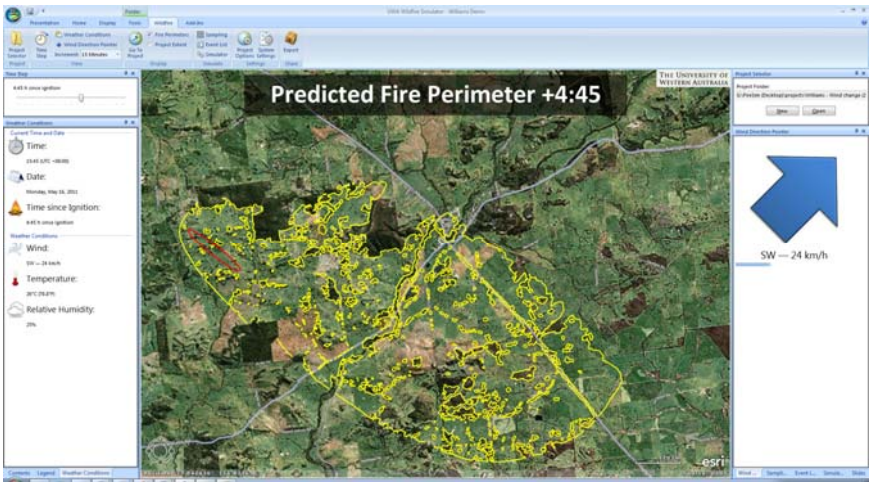


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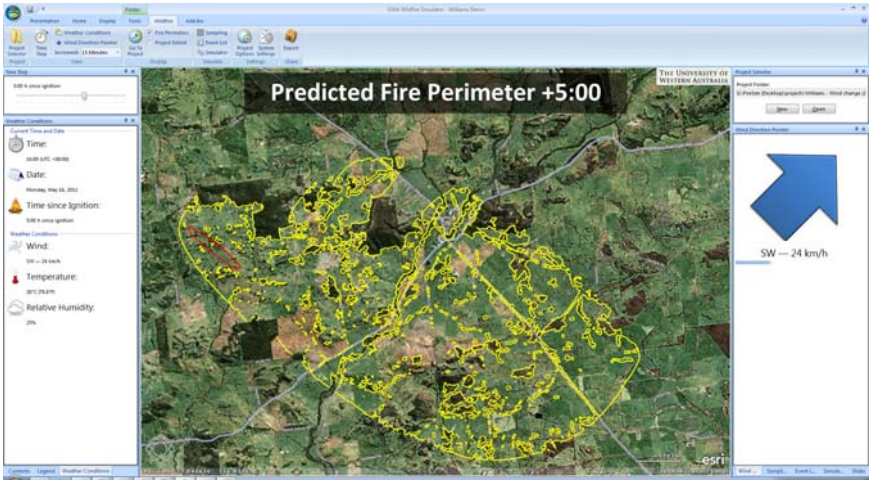


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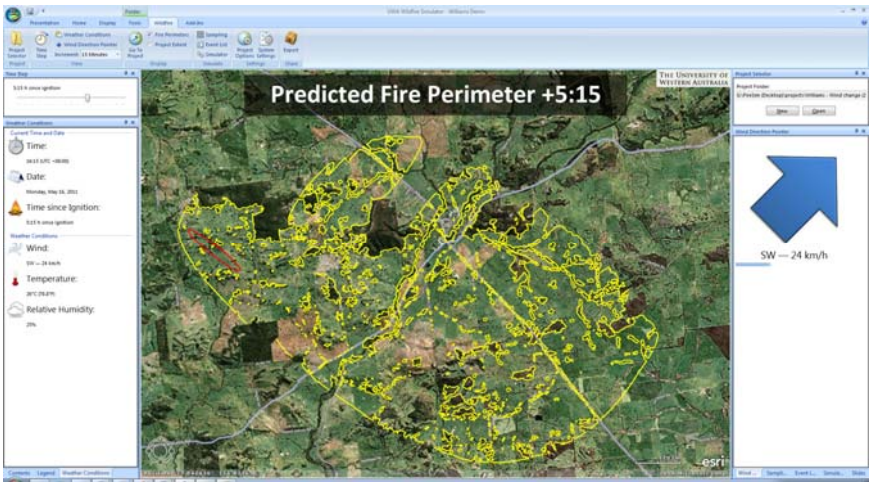


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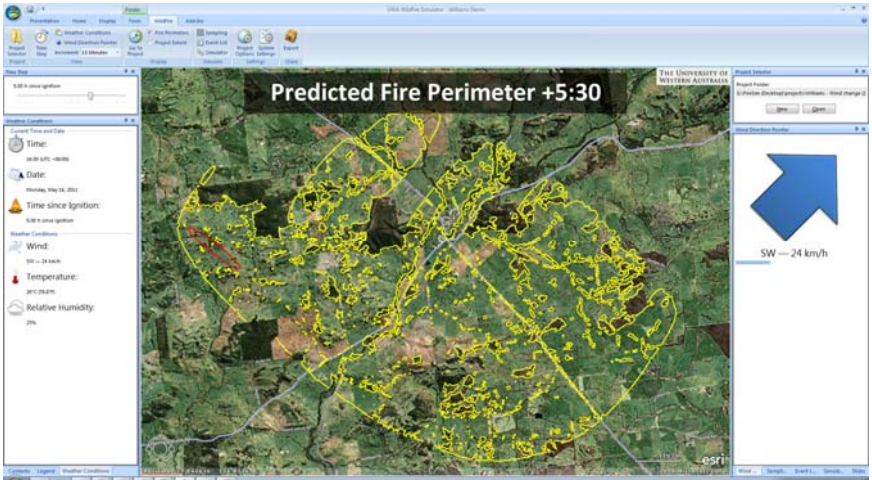


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## Simulating the Boorabbin Fire, WA

- *Fire progression perimeters* were reconstructed at high spatial and temporal resolution[A]
- *Simulation inputs* obtained from coronial reports into meteorological conditions[B] and fire development chronology[A]
- Simulations investigated the accuracy of *rate-of-spread models*, the effect of *length-to-breadth ratios* and *key sources of inaccuracy* (e.g. wind direction and vegetation map)
- Four phases were independently simulated: 1, 2, 3A and 3B

[A] Goldfields Fire 13 (Boorabbin Fire): Fire Development Chronology, GHD Pty Ltd, P. de Mar (2008)
[B] Meteorological aspects of the Boorabbin fire: 28 December 2007 – 8 January 2008, Bureau of Meteorology (2008)

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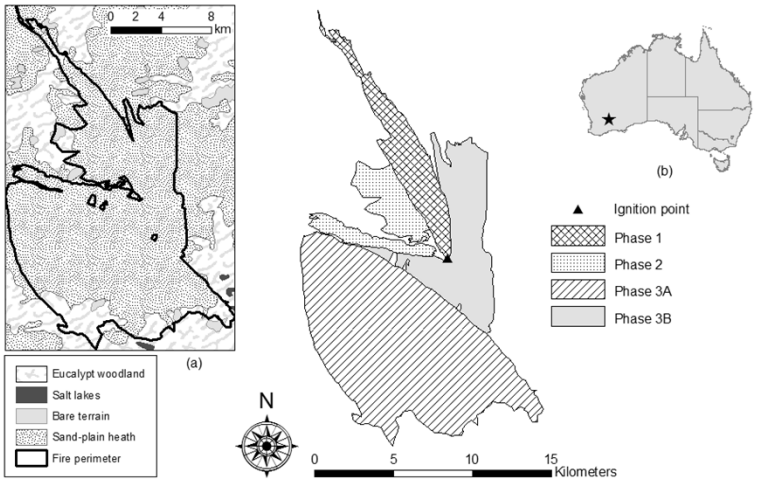
## Spatial extent of the Boorabbin Fire (28-30 December 2007)




Geo-referenced perimeters of the Boorabbin fire supplied by the Department of Environment and Conservation, Western Australia (DEC) and P. de Mar (GHD Pty Ltd)

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# Vegetation communities

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Sand-plain heath

Eucalypt woodland
(predominantly Salmon gum)

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# Meteorological conditions at Southern Cross AWS (~75 km W)

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| | Phase 1 | Phase 2 | Phase 3A | Phase 3B |
|---|---|---|---|---|
| Time (WDT; UTC+9) | 1200–2400 | 1100–1900 | 1100–2000 | 2000–2400 |
| Date | 28 December 2007 | 29 December 2007 | 30 December 2007 | 30 December 2007 |
| Area burned[A] (ha) | 2,200 | 1,950 | 10,000 | 3,700 |
| *Meteorological conditions*[B] | | | | |
| Temperature (°C) | 19–37 (31) | 25–35 (32) | 38–43 (42) | 20–38 (28) |
| Relative humidity (%) | 19–58 (30) | 18–36 (24) | 4–11 (7) | 9–68 (41) |
| Wind speed (km $h^{-1}$) | 18–39 (27) | 19–24 (21) | 22–44 (34) | 26–48 (37) |
| *Fire weather severity*[B] | | | | |
| Fire Danger Index (FDI) | 28 | 20 | 104 | 47 |
| Fire Danger Rating (FDR) | Very High | High | Extreme+ | Extreme |

Source: [A] (de Mar 2008); [B] Southern Cross AWS (Bureau of Meteorology 2008)

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## Accuracy of simulated perimeters (Phases 1 & 2)

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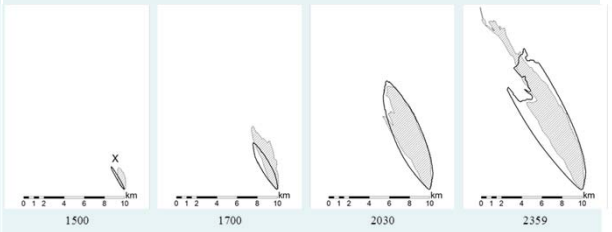
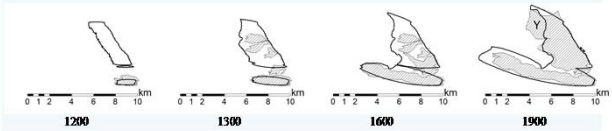
| | Accuracy | Simulations (semi-arid heath meter) |
|---|---|---|
| Phase 1 | K = 0.62 |   |
| Phase 2 | K = 0.52 |   |
| | |   |

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## Accuracy of simulated perimeters (Phases 3A & 3B)

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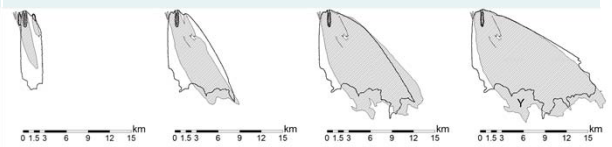
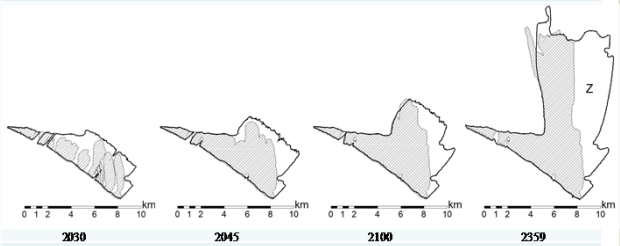
| | Accuracy | Simulations (semi-arid heath meter) |
|---|---|---|
| Phase 3A | K = 0.57 |   |
| Phase 3B | K = 0.56 |   |
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## Correcting for inaccuracy in wind direction

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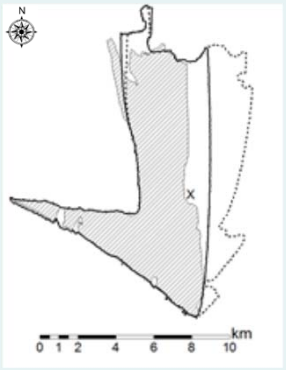
**Wind direction**

| Time (WDT) | Wind direction (°) | |
|---|---|---|
| | Observed at S. Cross AWS[A] | Inferred from reconstruction[B] |
| 2000 | 219 | 215 |
| 2030 | 210 | 180 |
| 2100 | 185 | 180 |
| 2200 | 182 | 180 |
| 2300 | 174 | 174 |
| 2359 | 172 | 172 |

[A] (Bureau of Meteorology 2008) [B] (de Mar 2008)

| Wind direction | Accuracy (K) |
|---|---|
| Observed | 0.56 |
| Inferred | 0.66 |

**Simulations**




Inferred Observed Reconstructed

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## Ongoing AUSTRALIS Simulator Research

- Use to infer RoS models from extreme bushfires
- But need high-quality fire data
  - actual fire perimeters at 30 min intervals
  - accurate fire-ground weather
  - accurate fuel mapping (pre and post fire)
- KEY MESSAGE simulation only as good as input data

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