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The AUSTRALIS Wildfire Simulator

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ARC Linkage Project:
Funding from ARC, FESA and Landgate

Digital Regions Initiative 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
- 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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Simulator System Overview

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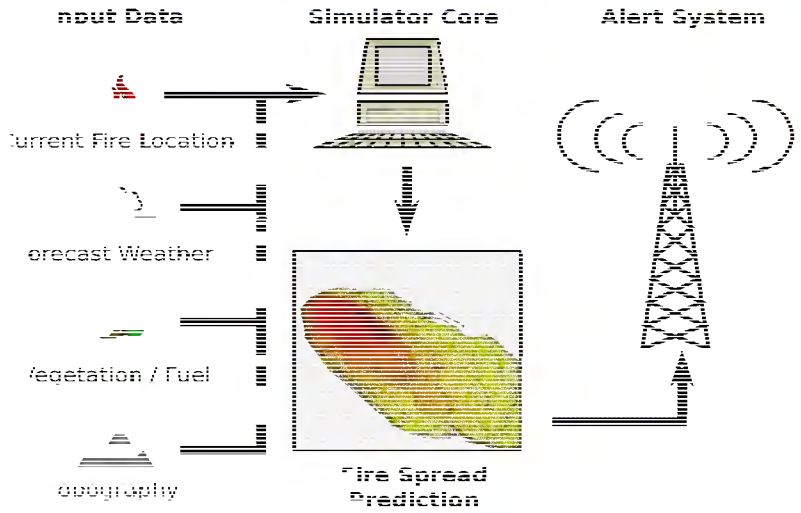

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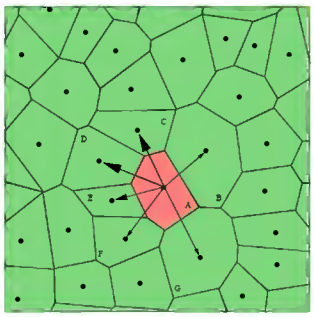
Fire Spread by Propagation Delay

- 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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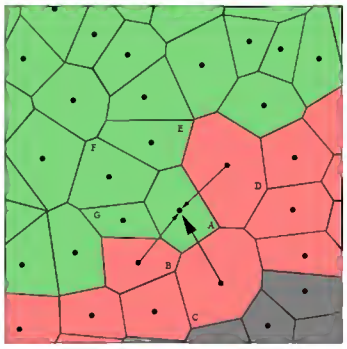
Spread over Landscape with wind from SE

- 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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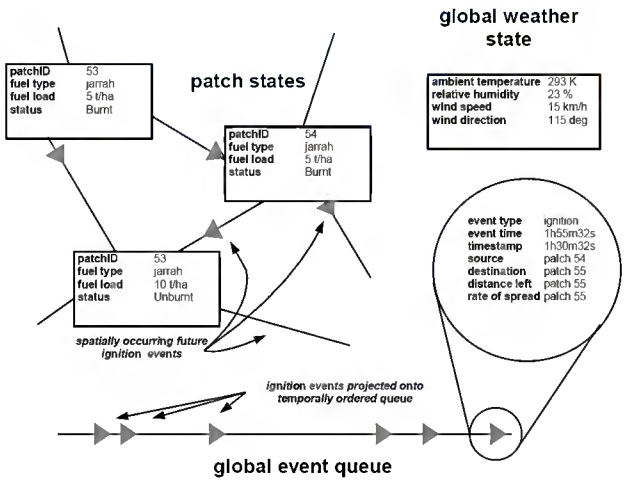
Discrete Event Simulation



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AUSTRALIS Simulator: validation using historical fires

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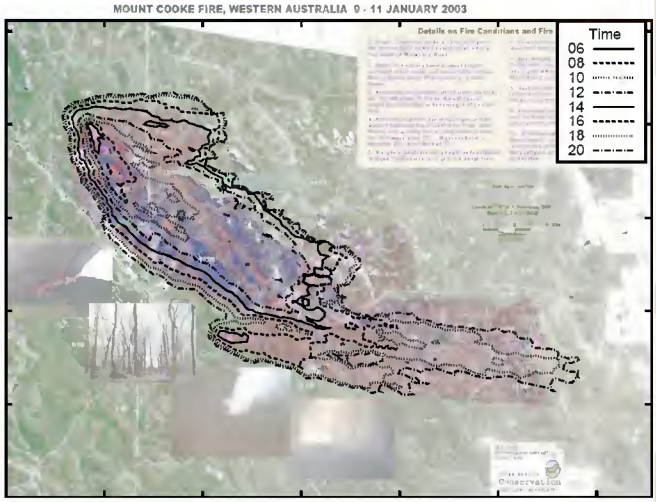
Mt Cooke fire simulation with fuel ages resulting from prescribed burning history



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Same scenario with no prior fuel reduction

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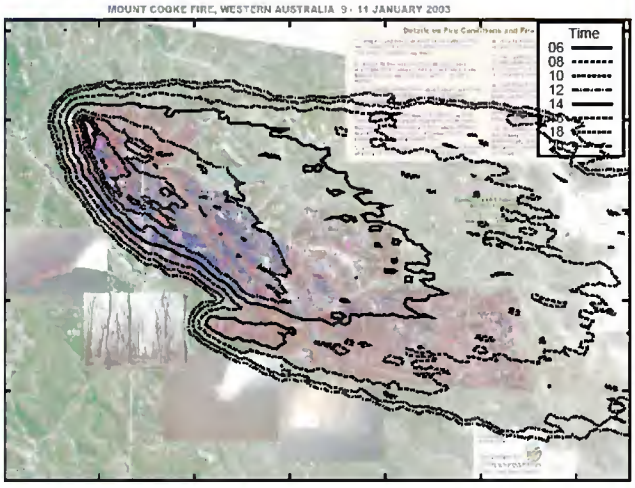
Mt Cooke fire simulation assuming all areas have 15 year old fuel



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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)
- current simulations 10km x 10km at 100m resolution (~7000 cells) 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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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
- Validate with "live" FESA data last fire season

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Australis Simulator Demonstration

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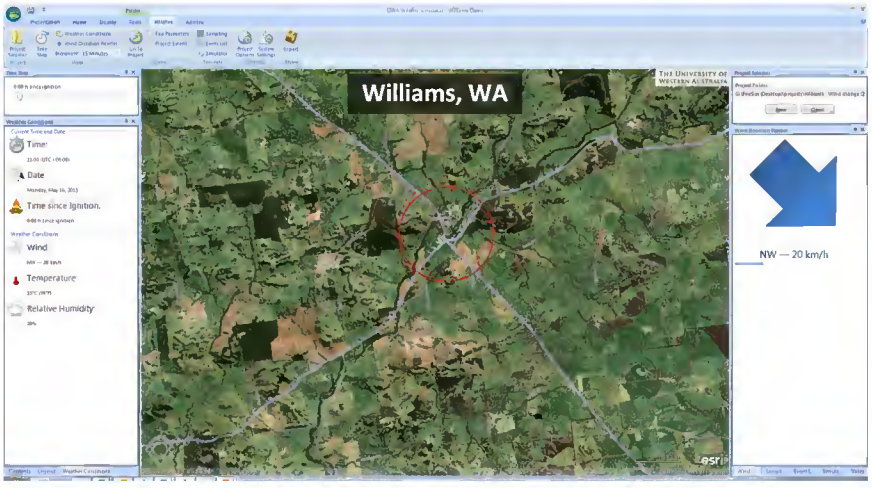

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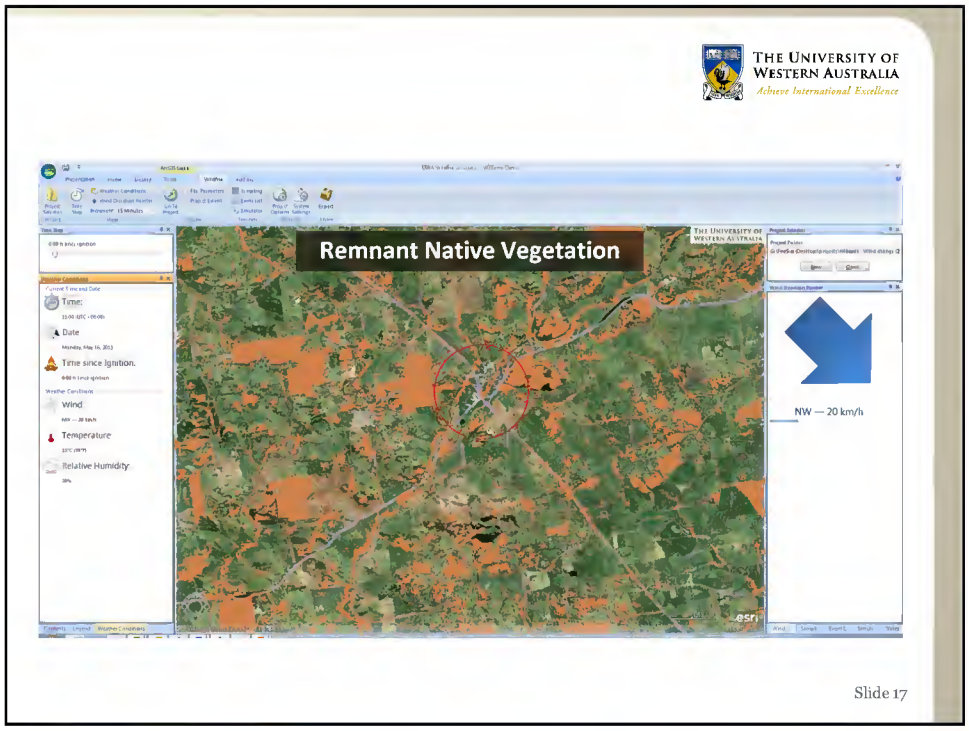
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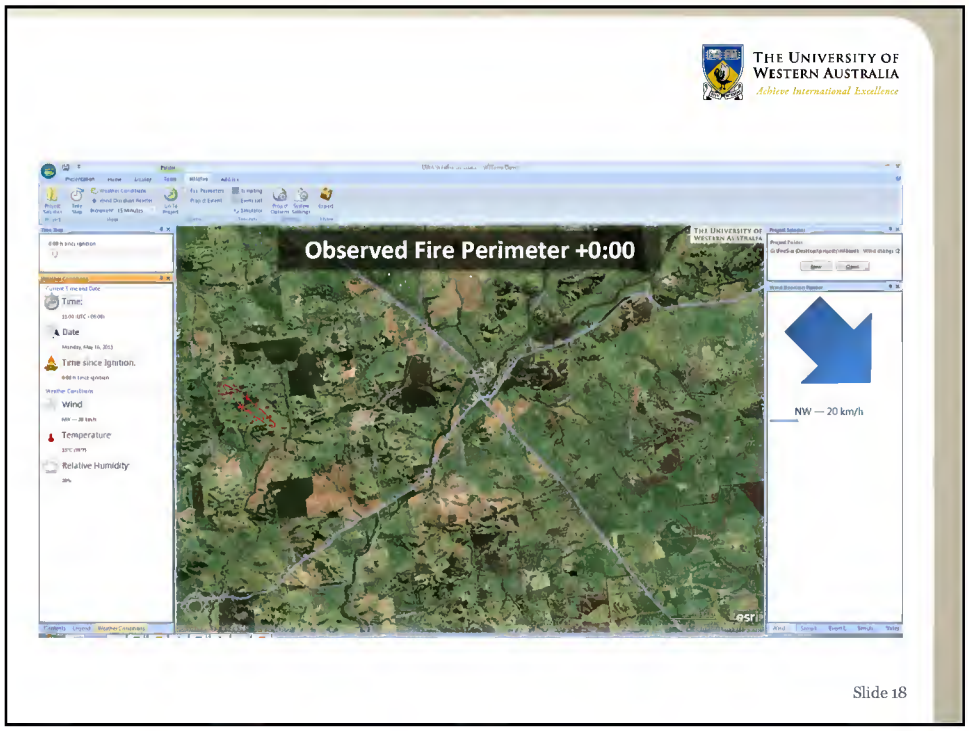
Remnant Native Vegetation
Time:
Date
Time since Ignition.
Wind
Temperature
Relative Humidity
NW — 20 km/h
Slide 17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Observed Fire Perimeter +0:00
Time:
Date
Time since Ignition.
Wind
Temperature
Relative Humidity
NW — 20 km/h
Slide 18

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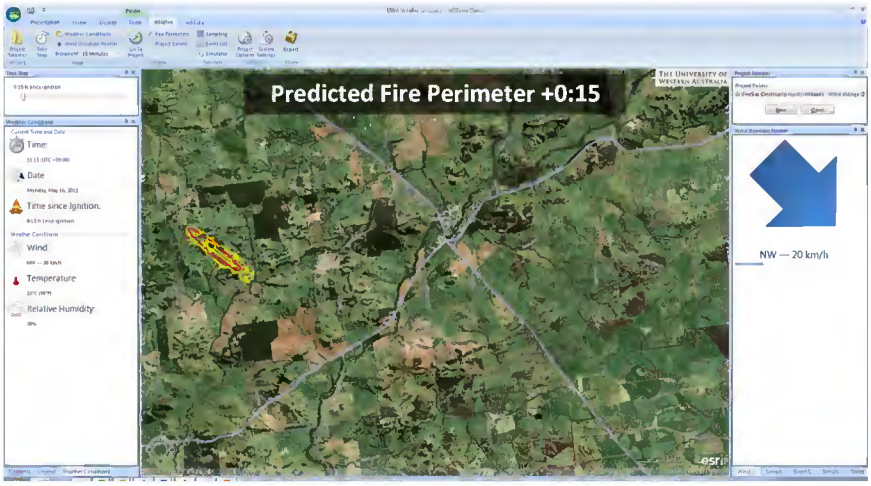

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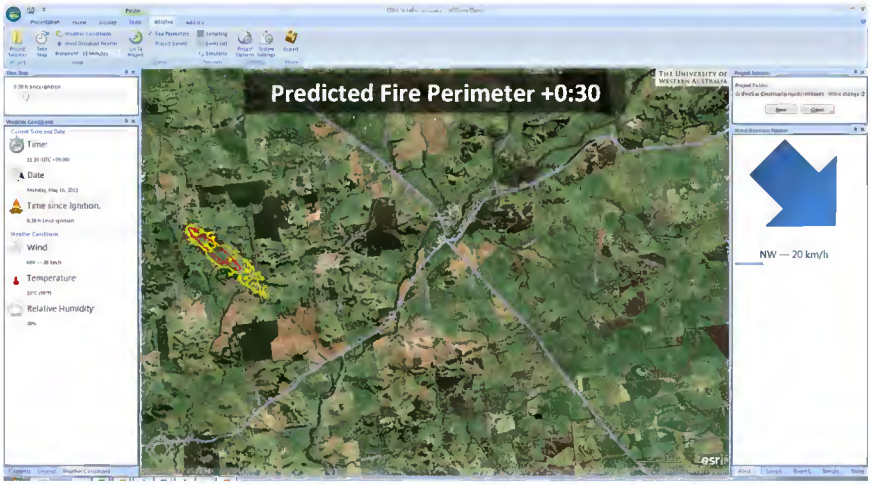

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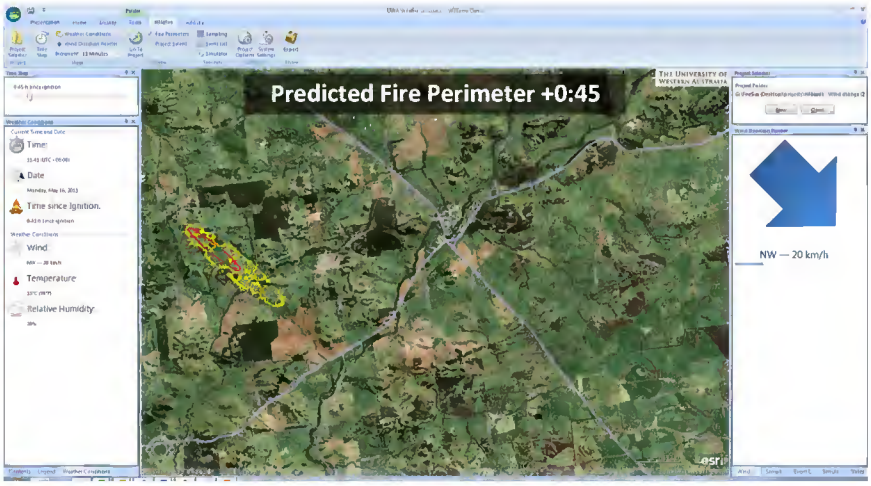

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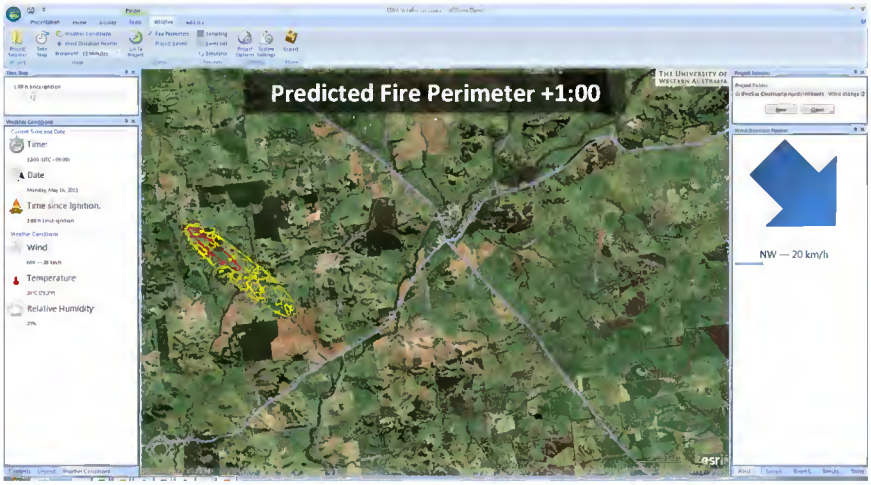

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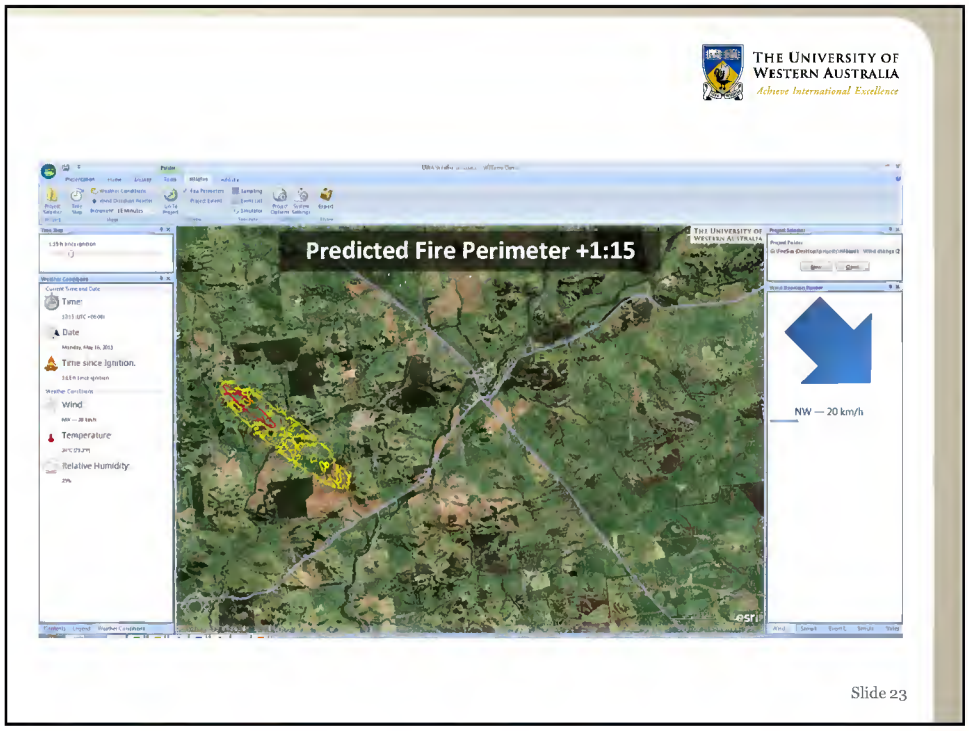
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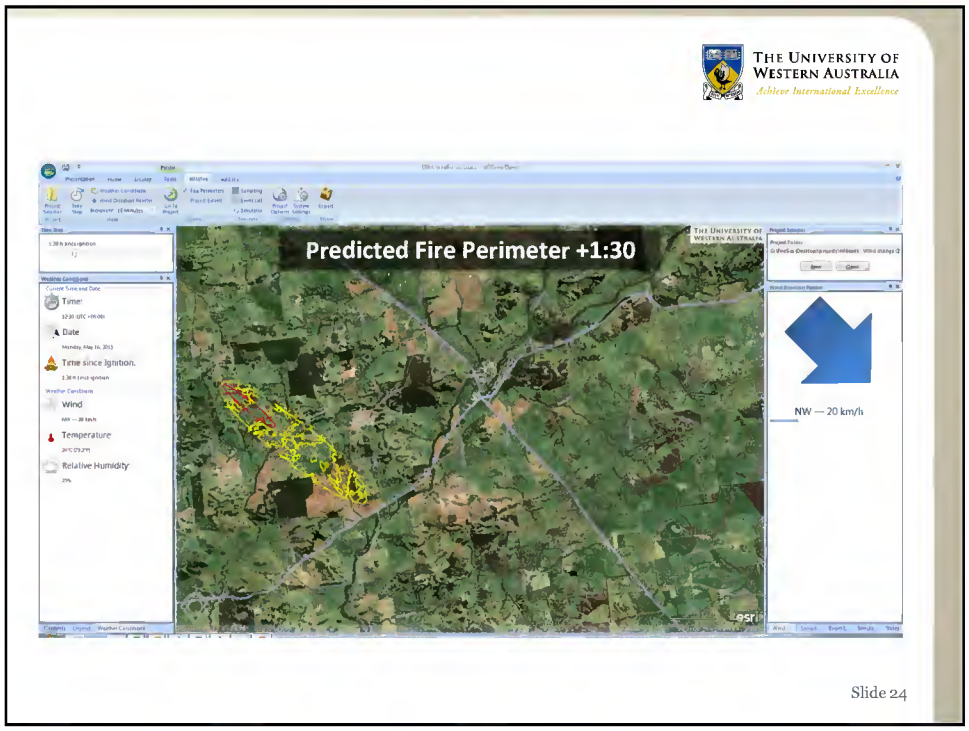
Predicted Fire Perimeter +1:15
NW — 20 km/h
Slide 23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Predicted Fire Perimeter +1:30
NW — 20 km/h
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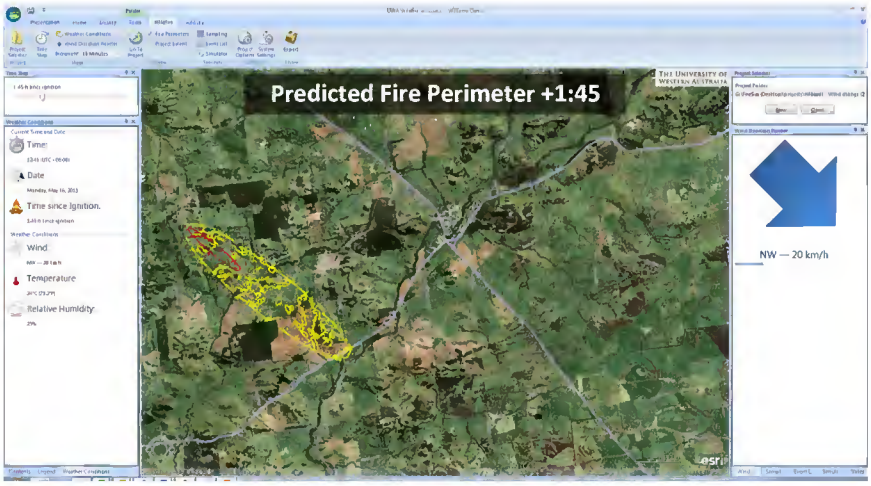

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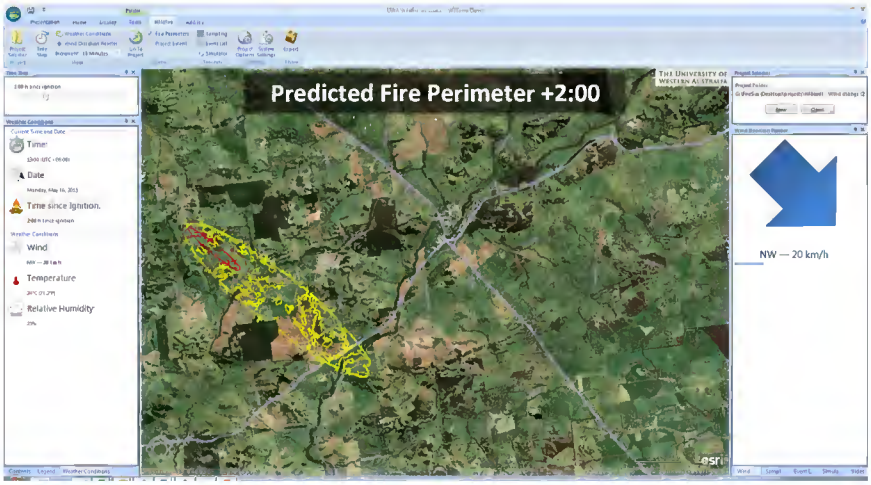

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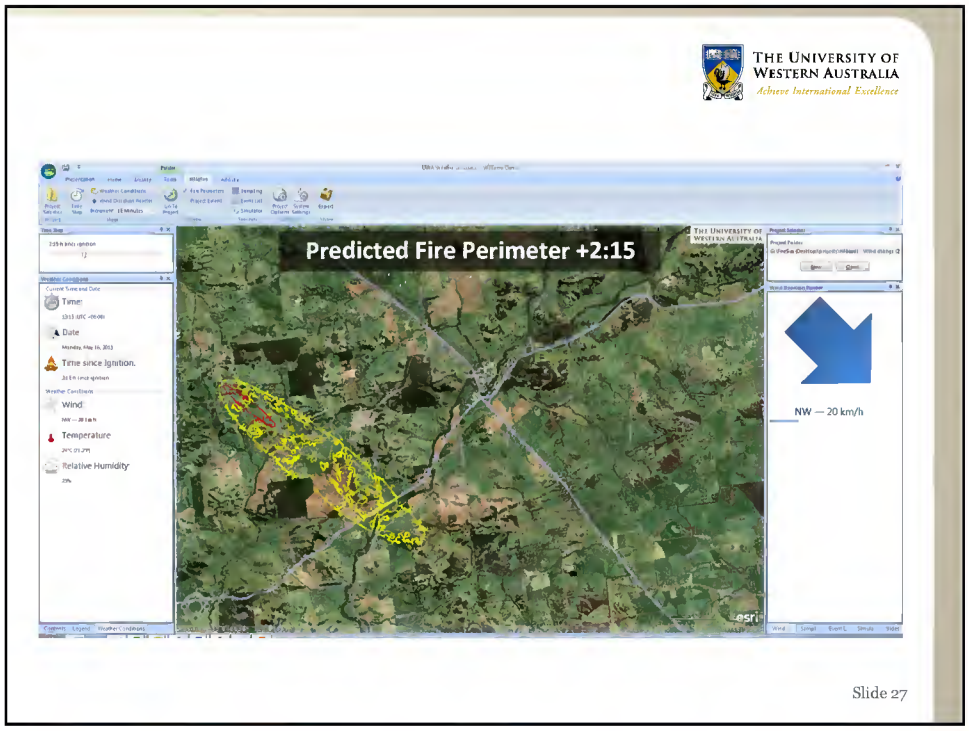
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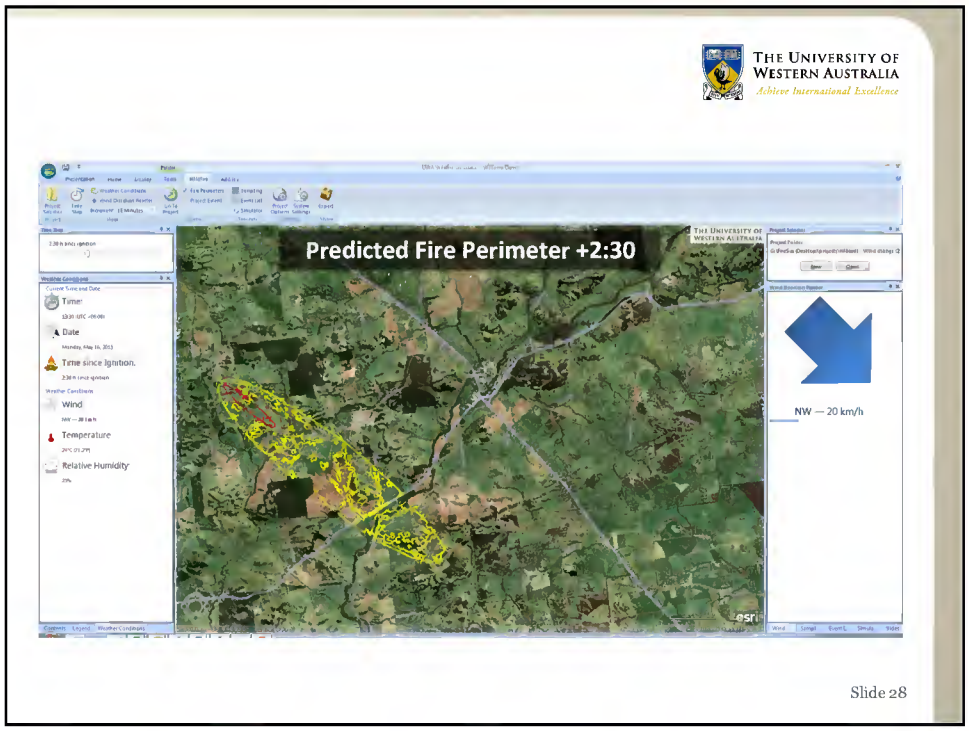
Predicted Fire Perimeter +2:15
NW — 20 km/h
Slide 27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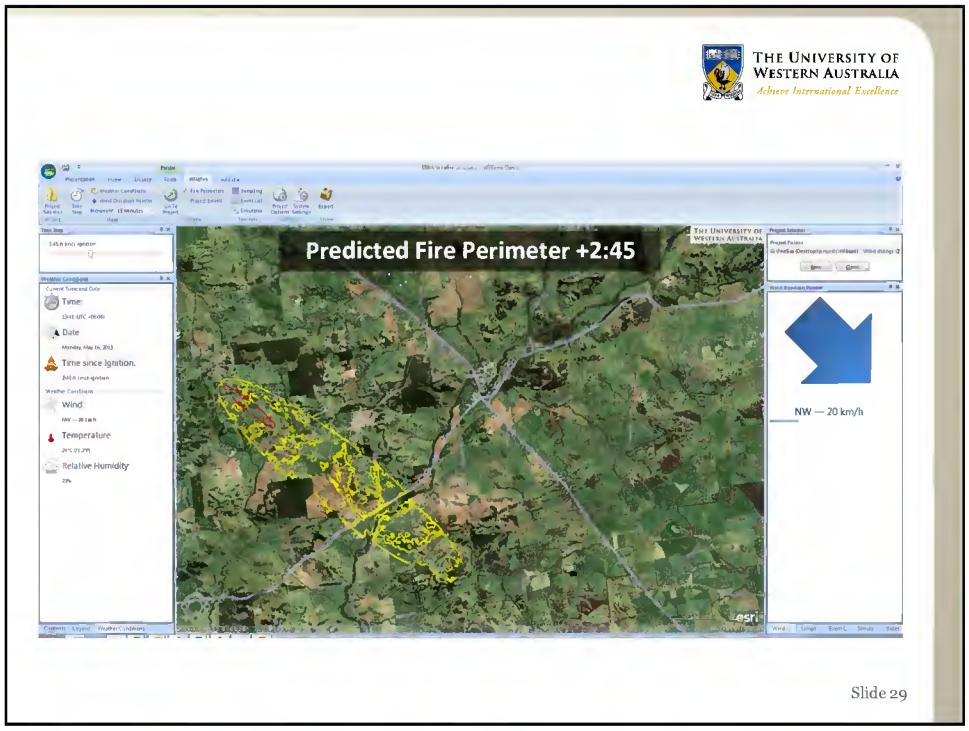
Predicted Fire Perimeter +2:30
NW — 20 km/h
Slide 28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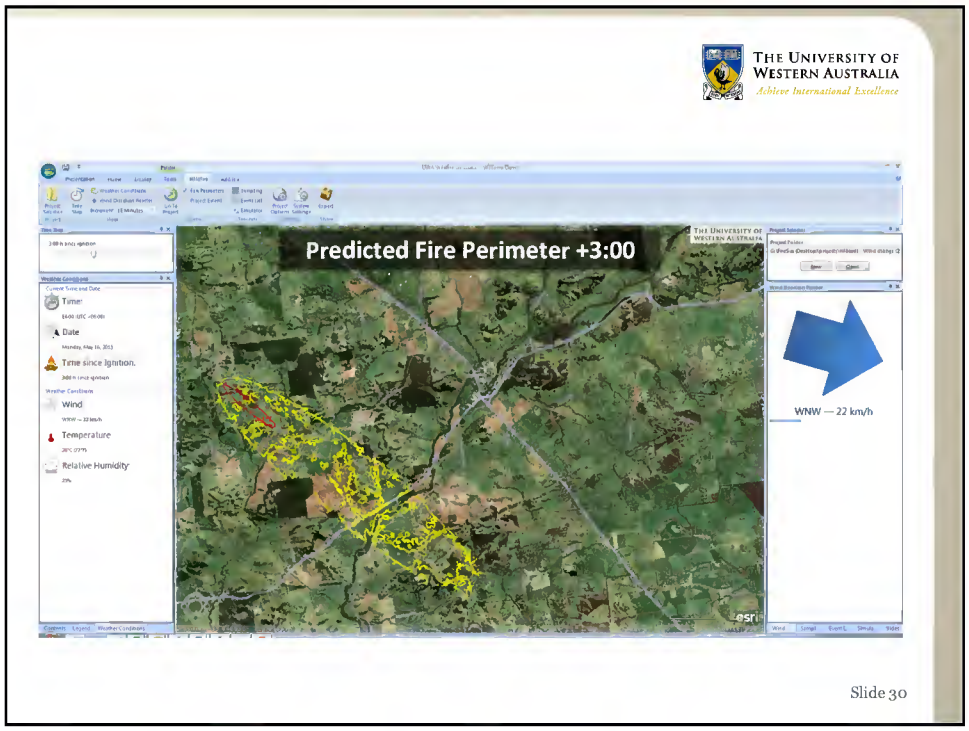
Predicted Fire Perimeter +2:45
NW — 20 km/h
Slide 29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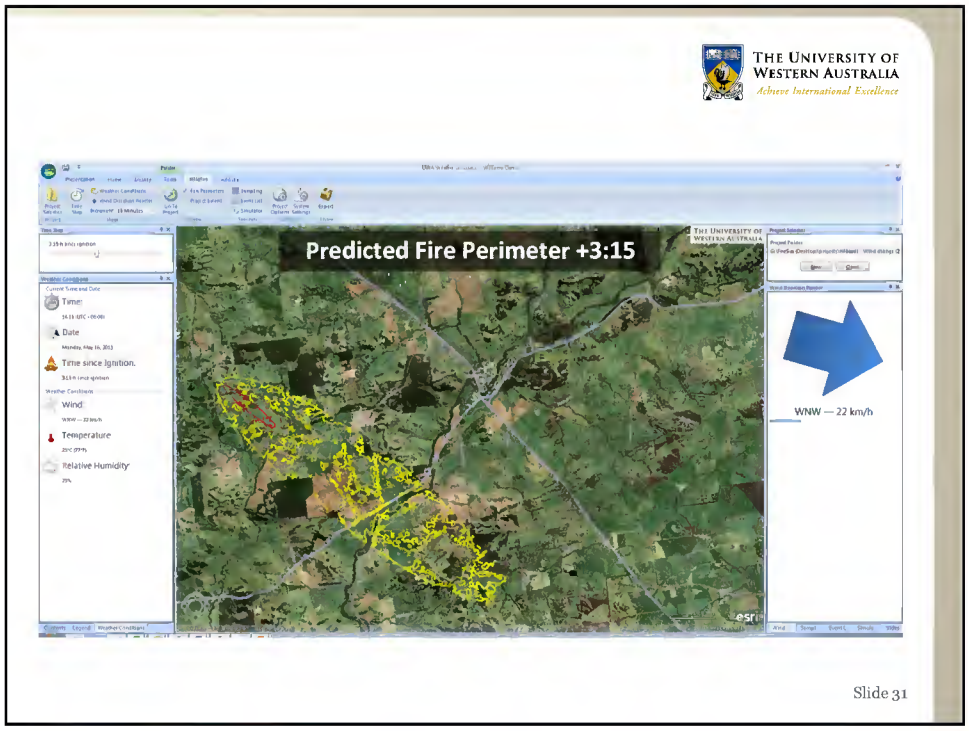
Predicted Fire Perimeter +3:00
WNW — 22 km/h
Slide 30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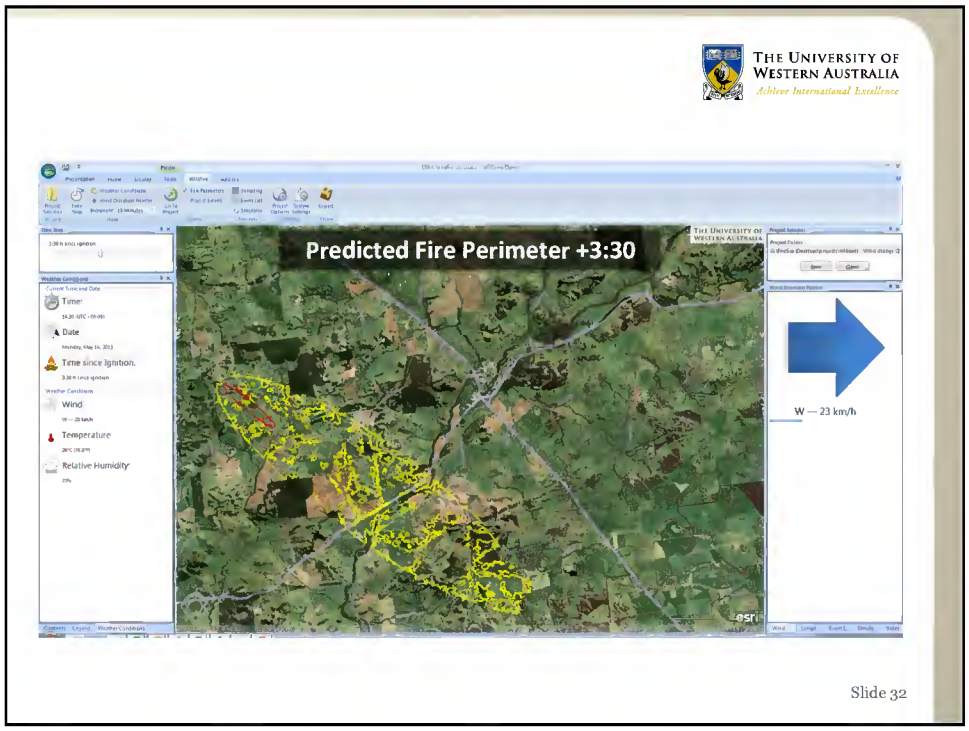
Predicted Fire Perimeter +3:15
WNW — 22 km/h
Slide 31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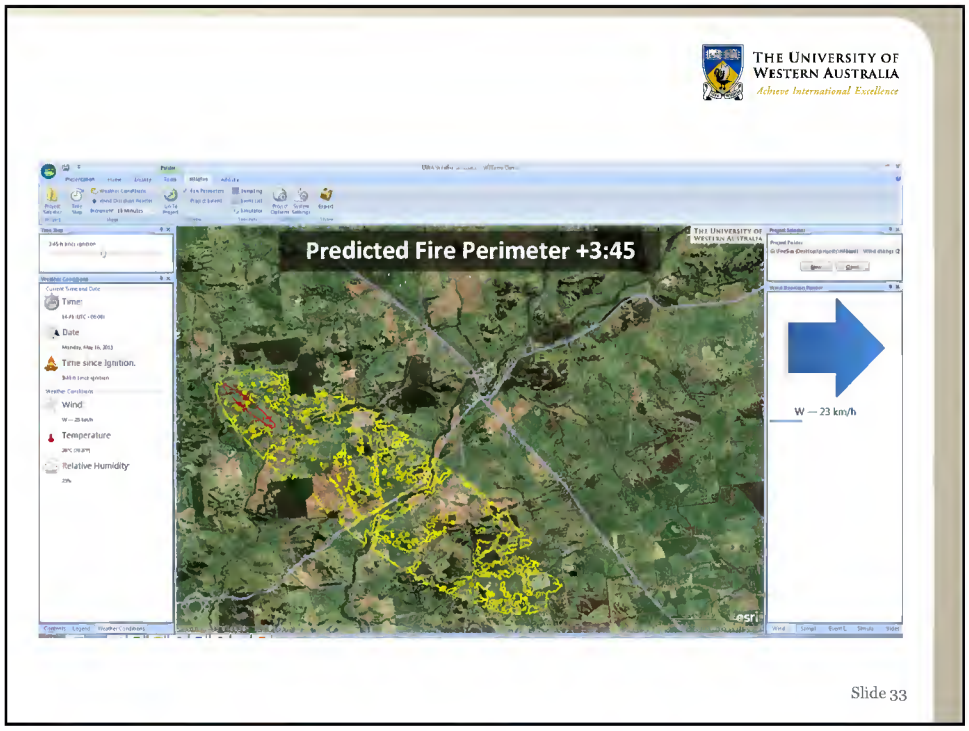
Predicted Fire Perimeter +3:30
W — 23 km/h
Slide 32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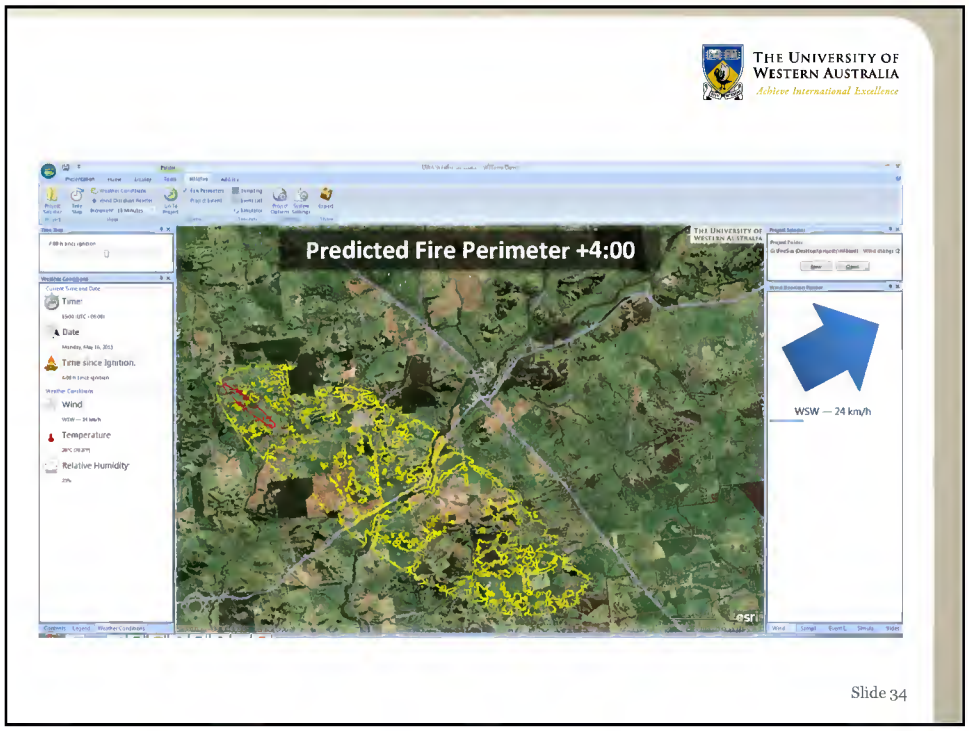
Predicted Fire Perimeter +3:45
W — 23 km/h
Slide 33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Predicted Fire Perimeter +4:00
WSW — 24 km/h
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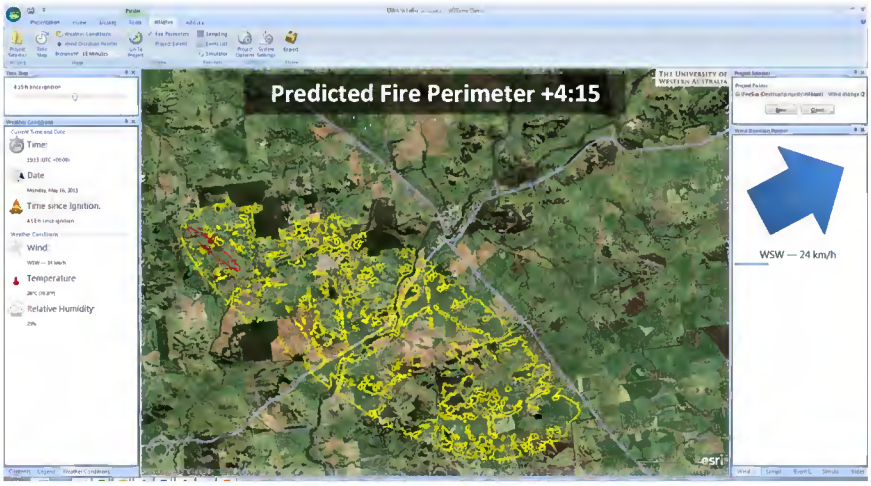

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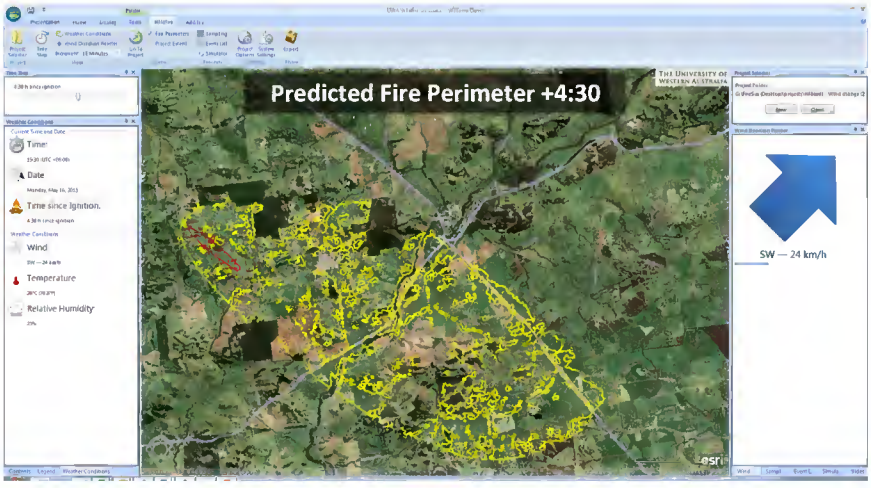

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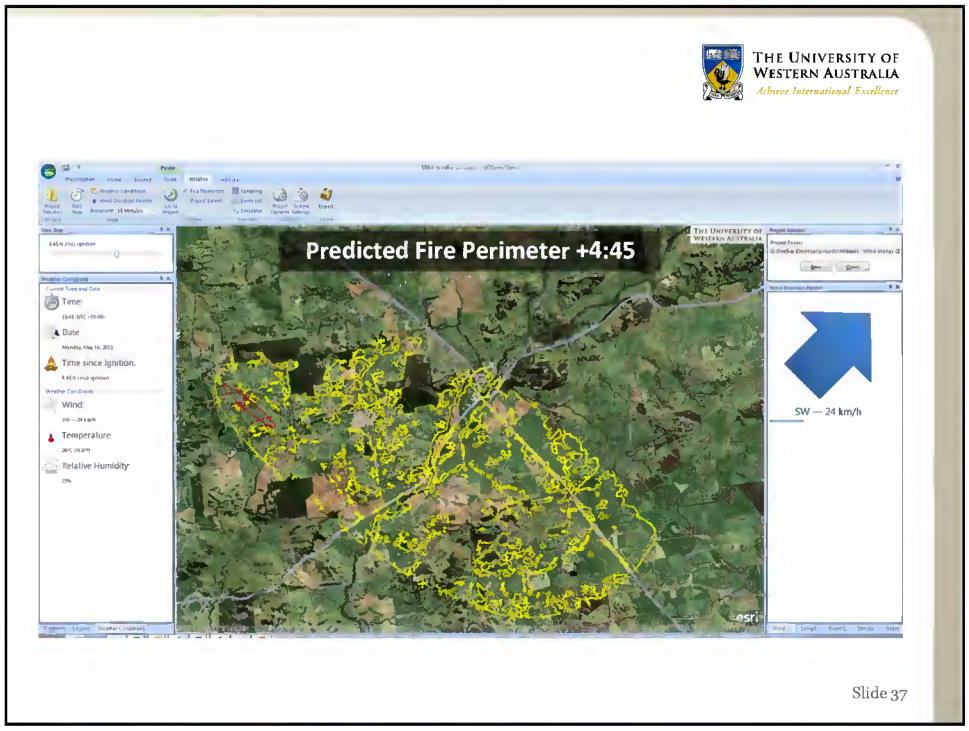
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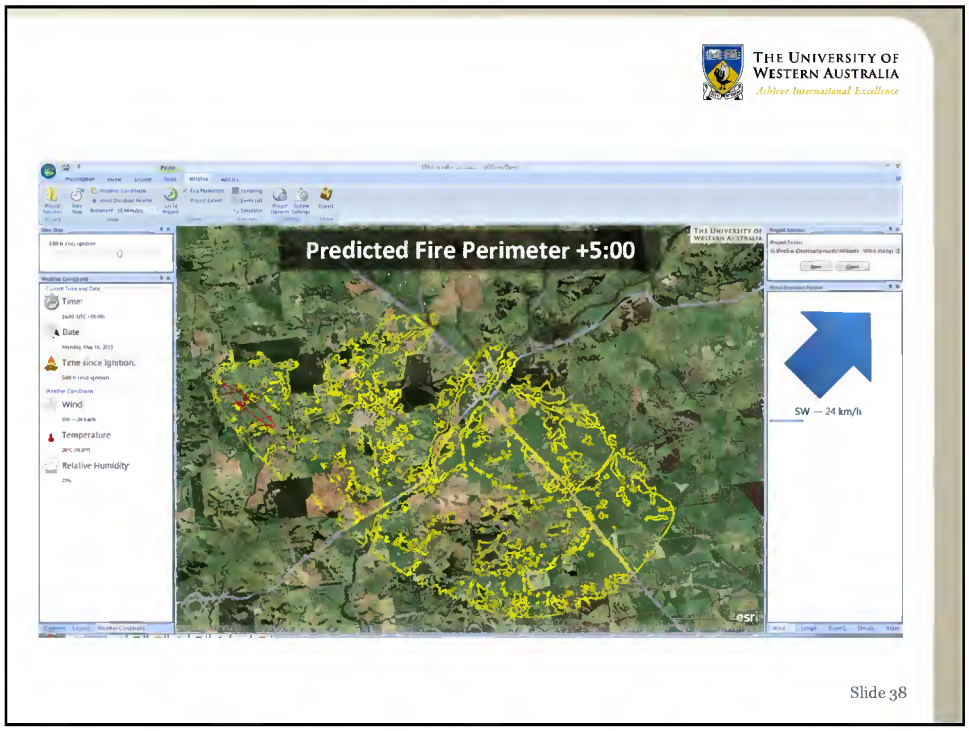
Predicted Fire Perimeter +4:45
Time:
Date
Time since ignition.
Wind:
Temperature
Relative Humidity
SW — 24 km/h
Slide 37


THE UNIVERSITY OF WESTERN AUSTRALIA
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Predicted Fire Perimeter +5:00
Time:
Date
Time since ignition.
Wind:
Temperature
Relative Humidity
SW — 24 km/h
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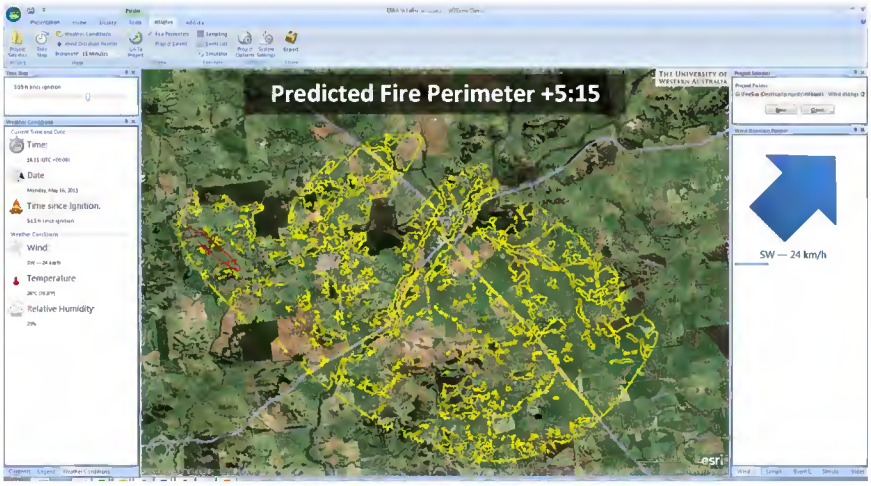

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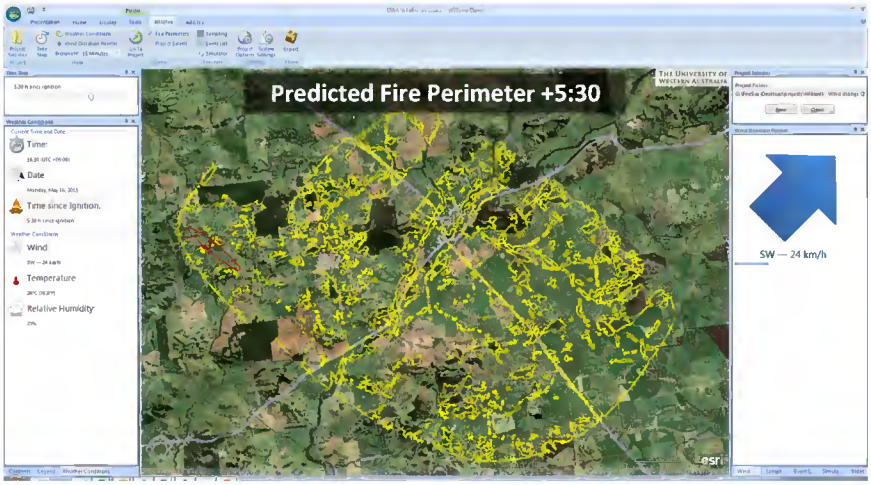

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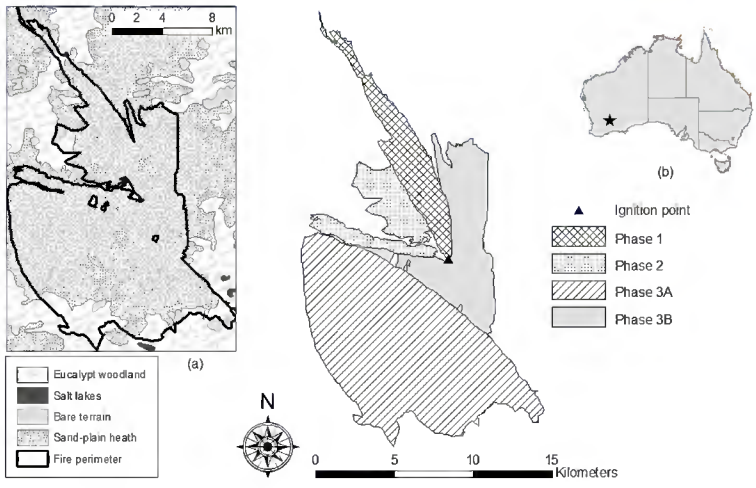
Simulating the Boorabbin Fire, WA

- *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 meters*, 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)

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)

Vegetation communities

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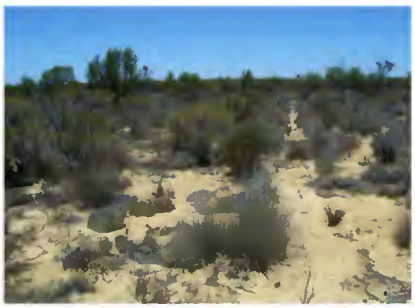

Sand-plain heath

Eucalypt woodland
(predominantly Salmon gum)

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)

Accuracy of simulated perimeters (Phases 1 & 2)

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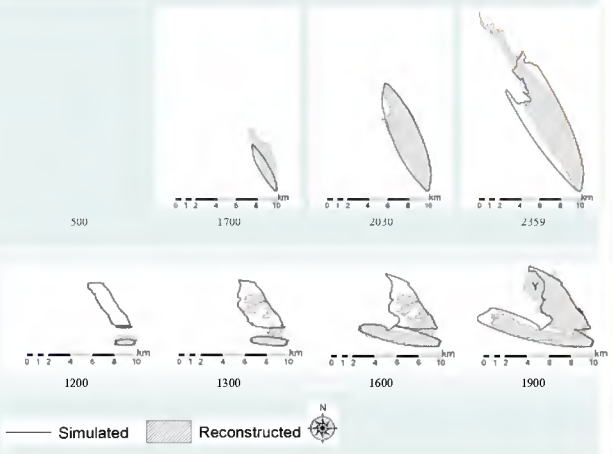
	Accuracy	Simulations (semi-arid heath meter)
Phase 1	K = 0.62	
Phase 2	K = 0.52	



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

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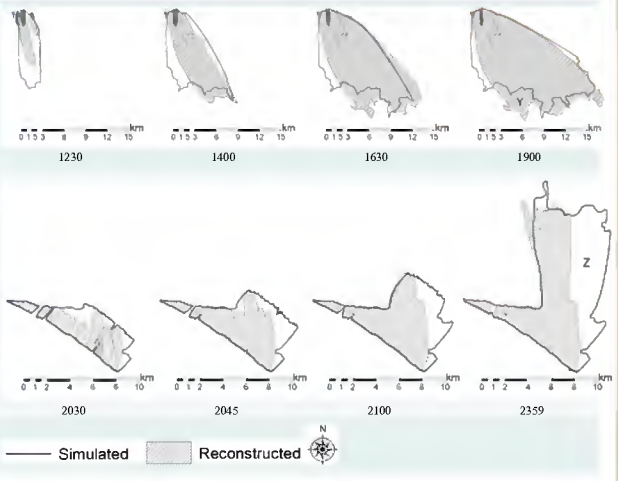
	Accuracy	Simulations (semi-arid heath meter)
Phase 3A	K = 0.57	
Phase 3B	K = 0.56	



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